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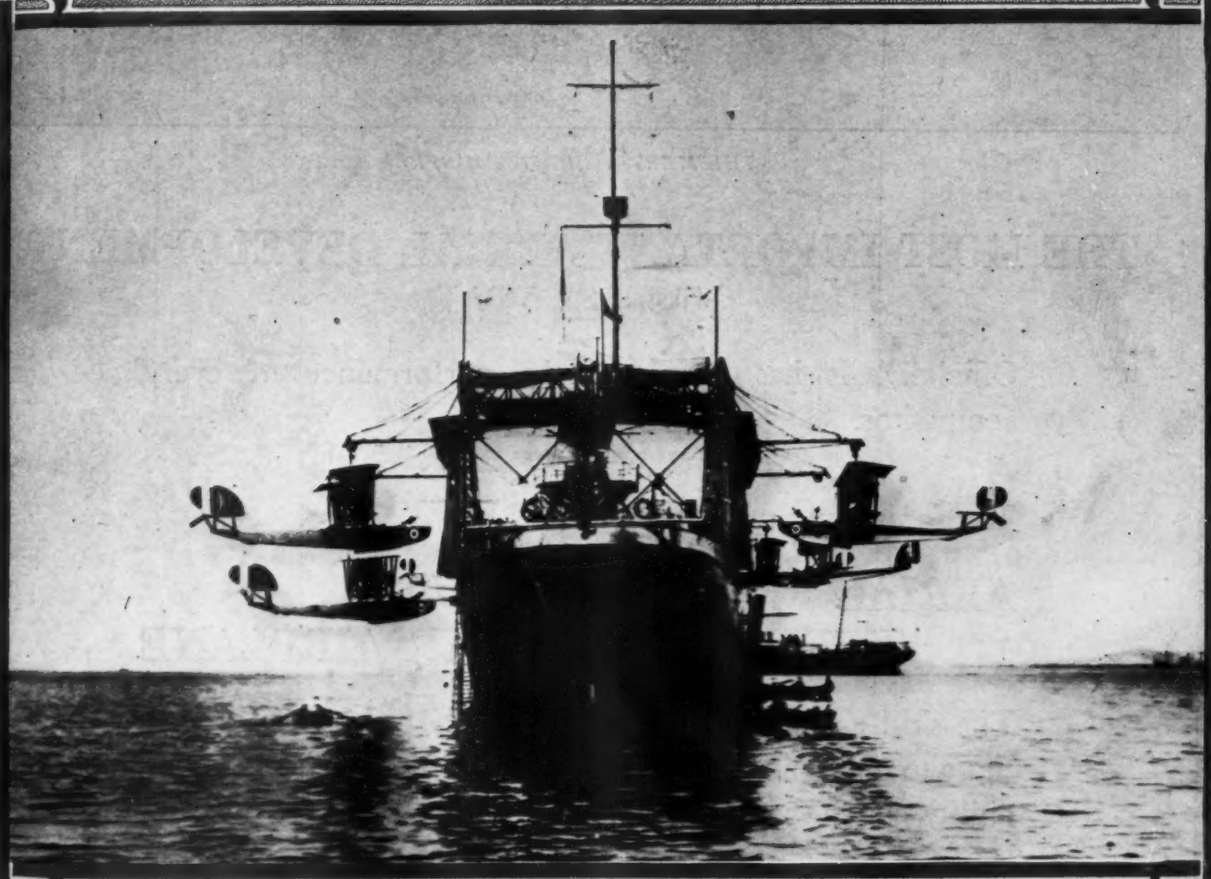

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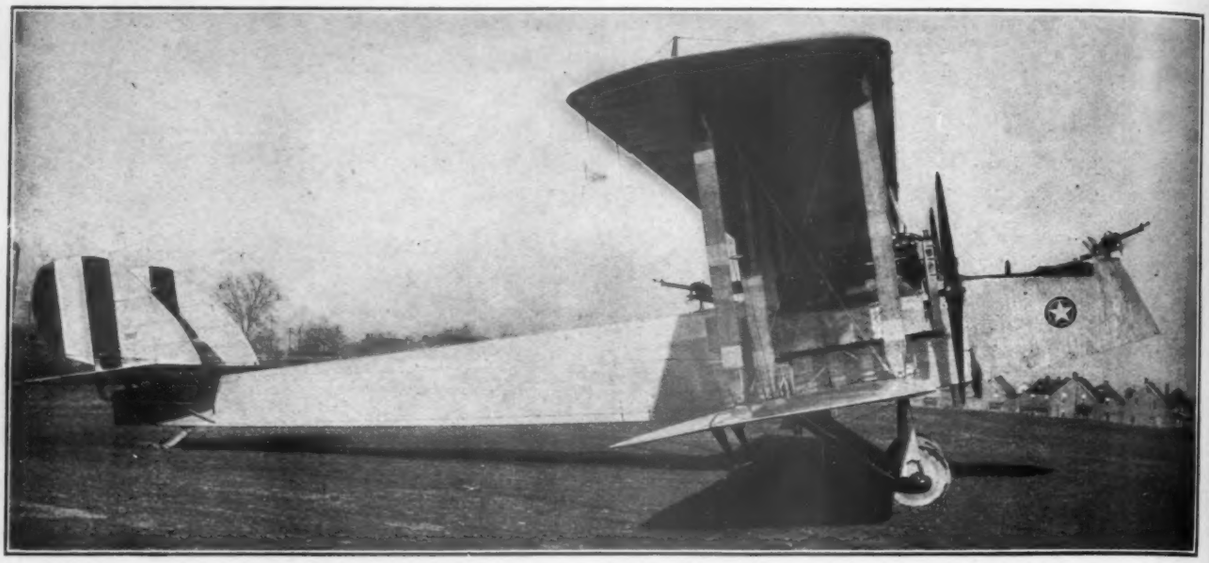

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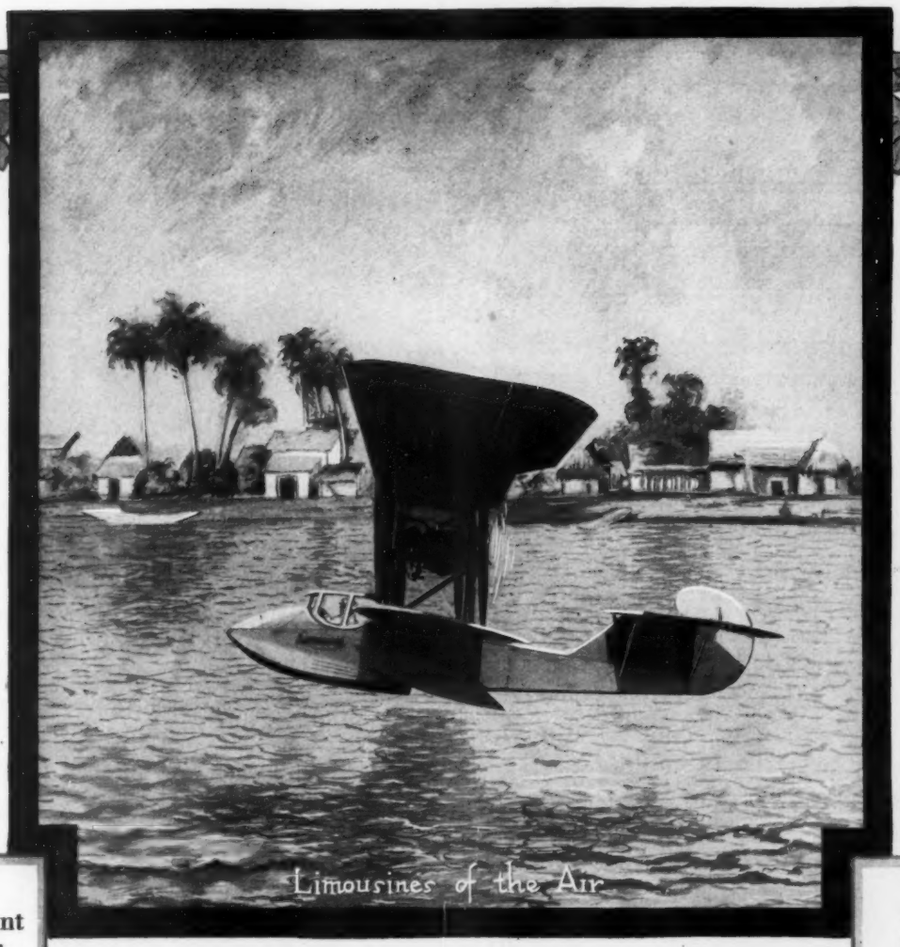

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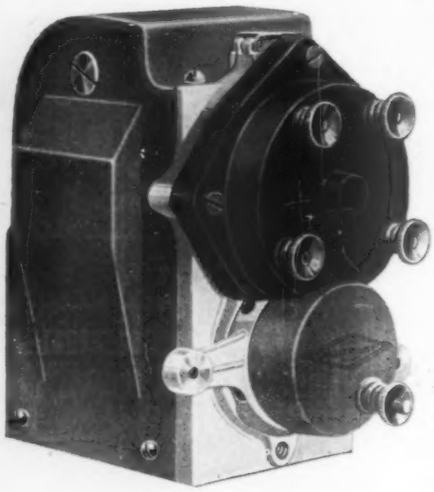

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AVIATION AND AERONAUTICAL ENGINEERING

VOL. VI. NO. 5

Member of the Audit Bureau of Circulations

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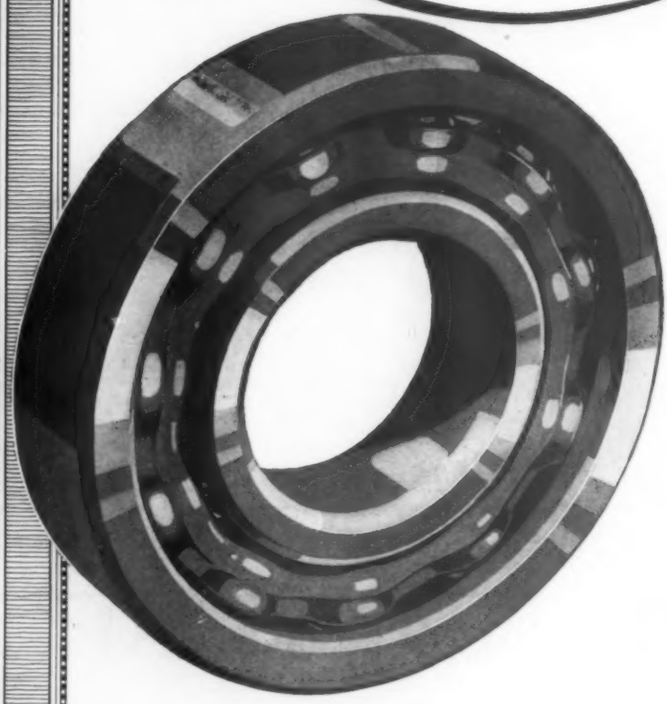

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Vol. VI | April 1, 1919 | No. 5

FOR some time past rumors have been current to the effect that with the general demobilization the Air Service was to be reduced to a mere skeleton, the intimation being that the billion dollars of war appropriations spent on the building up of our aircraft program would thus go to utter waste.

These rumors have fortunately proved unfounded. Not only will the aerial equipment available not be scrapped, but recommendations will be made for the purchase of 1,000 airplanes of the most modern type, particularly pursuit machines and bombers. The Air Service is woefully lacking in American made machines of these types, for our single-seater fighters and night bombers which were used in the war were all of foreign manufacture—a fact which the need for speedy action justified, but which no longer holds true.

The Division of Military Aeronautics also plans to purchase outright sixteen of the present flying fields and continue the lease on ten others. In addition facilities will be offered to air mechanics who should wish to enlist in the Regular Army after they have obtained their discharge from the National Army.

All these measures will go a long way to allay fears that the Air Service will drop back to insignificance when the new organization of the Army is carried out.

Requirements of the Mail and Passenger Plane

One of the most interesting problems confronting the aeronautical designer at the present moment is the large mail or passenger plane, differing possibly in detail of accommodation from one another, but belonging to the same class.

From the point of view of financial success, it seems absolutely essential that such planes should have large carrying capacity and considerable range or endurance. With small carrying capacity the overhead charges, and the salary of the pilot and of the mechanic figure too largely. Without large range and in view of the fact that either with mail or with passengers time is lost at terminals, the airplane only shows advantage over other types of transportation when a long range is possible. A practical minimum of 2,000 pounds of mail and of ten to fifteen passengers seems to be established, with a range of at least 400 miles. A cruising speed of at least 90 miles an hour seems to be advisable.

This constitutes sufficient specification for the designing engineer. The minimum horsepower with which the above load-carrying capacity and range can be achieved is certainly not less than 700 horsepower in the present stage of the art, and viewing the present available engine this means two or more Liberty twelves.

Although this minimum commercial end can be achieved with two Liberty engines, it is a serious question whether three engines are not better than two. A machine equipped with two engines, can in the event of one engine failing achieve its journey only with difficulty, and in the case of contrary winds only make headway very sluggishly. With three engines, two engines at full power would give the equivalent of what would be normally employed at cruising speed. With the failure of one of the engines of a twin engine job, the pilot will have considerable difficulty in resisting a tendency to spin, and even an extra compensating rudder may not be sufficient to overcome this. With a three engine machine the failure of the central engine will mean no discomfort in navigation at all, while the failure of one of the side engines will be less felt than for a two engine plane.

The introduction of three engines however, complicates the power plant. The problem arises whether the engines should be completely independent of one another, whether separate tanks should be available for each engine, whether these tanks should intercommunicate or not. The gasoline system thus becomes one requiring very careful study.

Furthermore, with the introduction of three engines, and the consequent possibility of cruising for a long period with one engine out of commission, it becomes a question whether it should not be possible to carry out minor repairs in the air. Around the center engine a roomy body or nacelle will with a little care give the mechanic all the space he needs. For the outer engines a gangway or railing should be provided, and when the mechanic does get to the engine some provision must be made to shelter him from the blast of the air.

The employment of multiple engines entails loss in aerodynamic efficiency. It becomes doubtful whether we are right in placing engines out on the wings, and whether it is not better to concentrate a multiple unit power plant, and to utilize a system of clutches working the motors together or separately, driving two propellers on the wings, or other numerous possible combinations.

To secure low landing speeds, yet not enlarge the wing area to such an extent as to destroy high speed, a consideration of movable flaps, or air-brakes of one type or another comes to the fore.

Stability, easily achieved with a suitable arrangement of dihedral and fin, becomes highly desirable.

There certainly seem to be a number of interesting problems connected with the design of this large type of airplane.

Course in Aerodynamics and Airplane Design

By Alexander Klemin

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Part III.—Experimental Aeronautical Engineering

In Part I of the present course, we dealt with Aerodynamical Theory and Data, in Part II with Airplane Design. In Part III it is proposed to deal with Experimental Aeronautical Engineering. During the war we have seen a tremendous development of the experimental side of aeronautical engineering. Broadly speaking the construction of every new machine is an experiment even if no systematic tests of any sort are carried out, and the testing is merely that of usage as in the early days. In a more restricted sense, experimental engineering is that technical branch of aeronautics which involves the systematic testing of an airplane or its component parts for the purpose of improvement or innovation, and this from the three main view points of (a) structural strength, (b) performance, (c) stability and controllability. This work although it may be concerned with the very latest developments is entirely distinct from the purely aerodynamic research of the physicist. It is engineer's work and should be carried on by engineers, even though the physicist may give the scientific foundation or help in devising accurate instruments. A very complete technique has grown up, and it is the principles and utilization of this technique that it is proposed to deal with in this part of the course.

Hitherto work of this character in the United States has been largely restricted to the Army and Navy Air Services. With the advent of peace it is hoped that this work will be taken up in earnest by the industry. A full employment of the tools now available, skilfully used by a great number of men will lead to a solution of the most pressing problems in aeronautics.

The subject may be subdivided in a different way into 1 Structural Strength, 2 Aerodynamics. In the experimental study of airplane strength, there will be dealt with at some length the principles and methods of sand testing, and ordinary strength testing will be touched upon. In the aerodynamical side of the subject, we shall deal with Full Flight testing for Performance —Speed, Climb and Ceiling, and with the methods employed in testing radiators and engines in the air. The discussion of full flight testing will involve besides the mathematical exposition of the subject a practical study of the preparation of the ship and instruments for the test. Certain possibilities in the testing of airplanes for stability and controllability will also be dealt with. In considering wind tunnel work we shall give descriptions of the various types of tunnels employed, the auxiliary apparatus available, and the principles and practice of operation.

Section 1.—Wing Truss Testing

However accurate and refined a stress analysis may be, and however strong it may be in its main members, such as spars, wires and struts, yet the wing truss may fail in the lug of a fitting or the crushing of a bolt embedded in wood, in which minor details computation may be entirely impossible and judgment alone must be relied upon. In the case of a machine of a novel type, or even of one with a slightly varied truss, an error may also creep into the stress analysis which may invalidate even the strength of the main members.

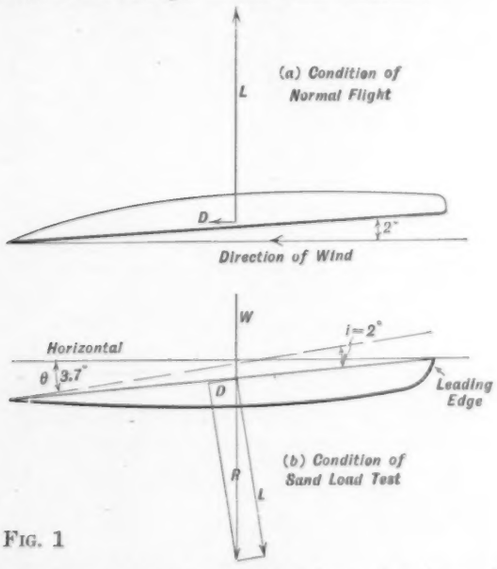


FIG. 1

At an expense which is negligible when safety is considered, it is possible to eliminate much of the uncertainty of structural design, by submitting the skeleton of a new machine to a sand test, in which air forces and dynamic forces in flight are simulated by the superposition of weights.

Conditions in the Air to Be Simulated

A difficulty arises in the very enunciation of principles, because we do not know what condition in the air we wish to simulate. Complicated maneuvers such as a spin or a barrel are quite beyond us at the present in the analysis of forces which come into play. We have therefore to consider simple maneuvers in one plane of action. A loop, a steep dive, and a sharp recovery from a steep dive are the three maneuvers which may be taken as imposing the severest stresses. As it is probable that in a loop skillfully executed the forces are inconsiderable, there remain the steep dive, and the recovery from a dive.

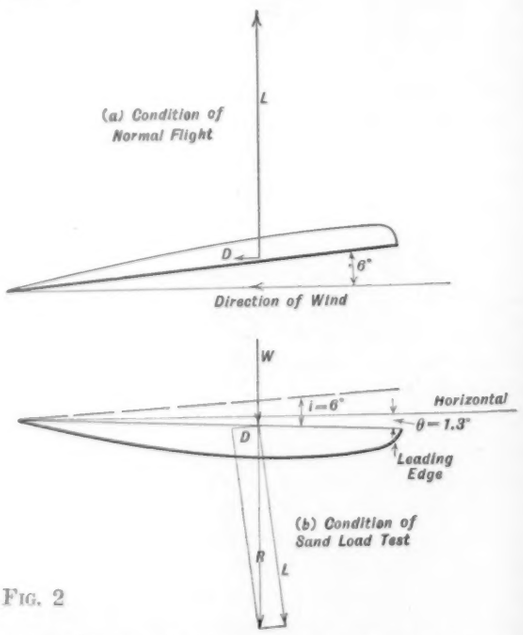


FIG. 2

In the steep dive the main forces acting on the wing are those of drag. The plane will, when it has attained its limiting speed, be at a very small angle of incidence and consequently small K_y coefficient, and the greater part of the weight of the plane will be supported by the drag forces on the plane.

On recovery from a dive a totally different condition occurs. The machine is diving steeply when the pilot pulls his elevator hard up and flattens out, describing a curve in space and imposing heavy centrifugal forces on the machine. In this case, before the machine has lost much of its diving speed, it has

been pulled up to a fairly large angle of incidence, bringing a very heavy lift load to bear on the wing truss, and the lift load on the wings is now much heavier than the drag load. No sand test can simulate both conditions, and hence a controversy is always possible as to the exact proportion of drag to lift which should be imposed in sand testing. As a compromise the tests of common practice are carried out under such conditions that the lift to drag ratio is as 4:1. This purely conventional loading at least simulates to some extent the conditions existing under a heavy dive, and at the same time we get a sufficiency

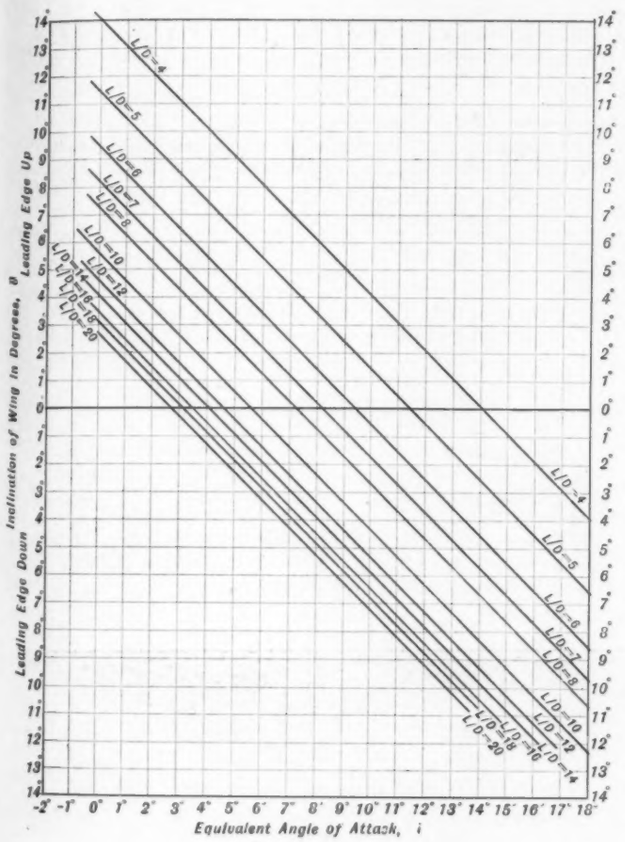


FIG. 3

of lift loading. Once adopted, and all machines being tested in the same way, we get at least comparative figures.

There arises the question of upside down loading on the wings. Here the problem is still more confused. From an investigation of a mathematical character carried out some time back by the author it would hardly seem as if in a well executed loop any reverse lift is imposed on the wings. It may be that in a badly executed loop such load is indeed imposed on the wings. Also real upside down flying, the barrel, and other stunts, may momentarily impose a reverse loading on the wings. On a rough landing too, the effect of a reverse load on the wings is produced.

Elementary Theory of Sand Loading

(A) Normal Upward Lift on the Wings

Fig. 1 illustrates how the lift and drag components may be replaced by the simple force of gravity. The wing is taken to be in normal flight at an angle of 2 deg. to the relative wind, and the lift drag ratio under these conditions is 10. If under sand load the wing is placed upside down with its leading edge up at an angle of 3.7 deg. with the horizontal, the components of the gravity force along, and perpendicular to, the chord will have the same relative values as the components of the lift and drag along and perpendicular to the chord. A simple analysis will demonstrate this.

Resolving forces along and perpendicular to the chord we have:

1. In flight

$$D\cos i - L\sin i \quad \text{and} \quad D\sin i + L\cos i$$

2. In sand load

$$W\sin\theta \quad \text{and} \quad W\cos\theta$$

and writing

$$\frac{D\cos i - L\sin i}{D\sin i + L\cos i} = \frac{\frac{L}{10}\cos 2^\circ - L\sin 2^\circ}{\frac{L}{10}\sin 2^\circ + L\cos 2^\circ} = .065$$

while

$$\frac{W\cos\theta}{W\sin\theta} = \tan 3.7^\circ = .065$$

There are however an endless number of cases which it is possible to simulate by sand loading.

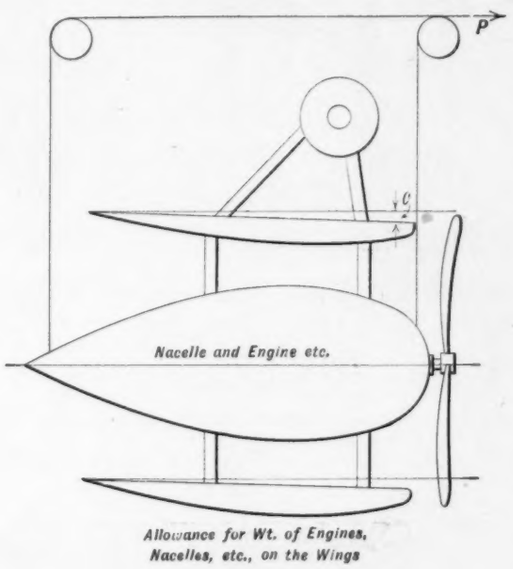


FIG. 4

If $D\cos i - L\sin i$ has a negative value, then the leading edge of the wing has to be down. Take for instance the case where we have to simulate a flight condition at an angle of incidence of 6 deg. and an L/D of 12. In this case, as shown in Fig. 2, the leading edge of the wing is shown, and giving the forces along the chord acting downward a negative sign, we have

$$\frac{D\cos 6^\circ - L\sin 6^\circ}{D\sin 6^\circ + L\cos 6^\circ} = -.0216$$

and

$$\tan -(1.3^\circ) = -.0216$$

The chart Fig. 3 gives data for every possible case.

(B) Reverse Load on the Wings

For the case where there is a reverse or down load on the wings in actual flight, the sand loading, to simulate this condition, will take place with the wing truss unreversed. This follows immediately by similarity, and does not require a special demonstration.

Allowance for Weight of Wings in Sand Testing

In loading the wings for any factor of safety n, the sand load required is given by the formula:

$$W_n = n(W_g - W_w) - W_w.$$

Where W_n is the sand load to be imposed for factor of safety n, W_g is the gross load of the machine, and W_w is the weight of wing truss.

In the expression $n(W_g - W_w)$, W_w is deducted on dynamical grounds. If a dynamic load of value n is imposed on the machine, and is taken up by the lift, then the extra weight of any part of the wing is immediately taken up by the lift at that point without imposing extra stresses on the truss. Again, when sand loading begins, W_w is itself an imposed load and may be deducted from the sand loading.

Allowance for Weight of Loads on Wings in Case of a Twin Engine Machine

In the case of loads carried on the wings, an allowance for weight of engines, nacelles or fuselages, etc., carried on the wings must be made by applying upward pulls at the appropriate points by means of blocks and tackle.

If W_a is the weight carried in flight on either of the wings, and W_b is the weight of that portion of the load which is

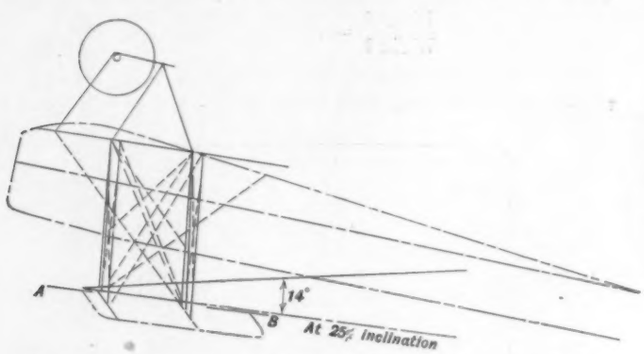


FIG. 5. GENERAL ARRANGEMENT FOR SAND LOADING TEST

actually present in the sand test and carried on the wings (this is less than W_a, since fuel will not be present, tanks and instruments may be removed, etc.), then for a factor of safety n, an upward load must be applied, as shown diagrammatically in Fig. 4 and expressed by the formula

$$P = nW_a + W_b.$$

This is self-explanatory. When in the air, the airplane sustains a dynamic loading n, and the wing stresses are evidently relieved to the extent nW_a on either side. On sand test W_b, instead of relieving the wings, is an extra imposition of load which has to be taken up by the pull of the block and tackle.

Inclination of Wings in Reversed Truss Sand Loading

The British test with the leading edge up and the chord at 8 deg. This would correspond to an angle of incidence of 1 deg. and an L/D of about 7. The center of pressure is placed at ⅓ of the chord from the leading edge in such tests, although with this small angle of incidence, the center of pressure on a wing would be much further back.

In French tests, the inclination of the wings is 25 per cent of the chord, corresponding to an angle of inclination of 14 deg., and the center of pressure is taken between ⅓ and ¼ of the chord from the leading edge. This would correspond to a small angle of incidence, about 1 deg., and an L/D of 4. As stated previously, this has been adopted as a standard in the United States, and is a fairly satisfactory compromise. The arrangement of wings on such a test is shown diagrammatically in Fig. 5.

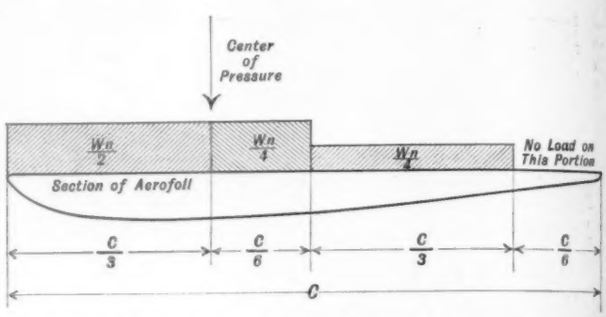


FIG. 6. DISTRIBUTION OF LOAD ALONG CHORD OF WINGS

Distribution of Loading Over Wings

Aerodynamic pressure diagrams over the wing surface indicate a progressive falling off from the center of the wing to the tips, but, since this is indefinite and a uniform loading gives greater pressures, it is accurate enough to distribute load uniformly over the wings. Where wings are rounded off at the tips, an accurate loading would be very complex, and it is sufficiently accurate to disregard this area.

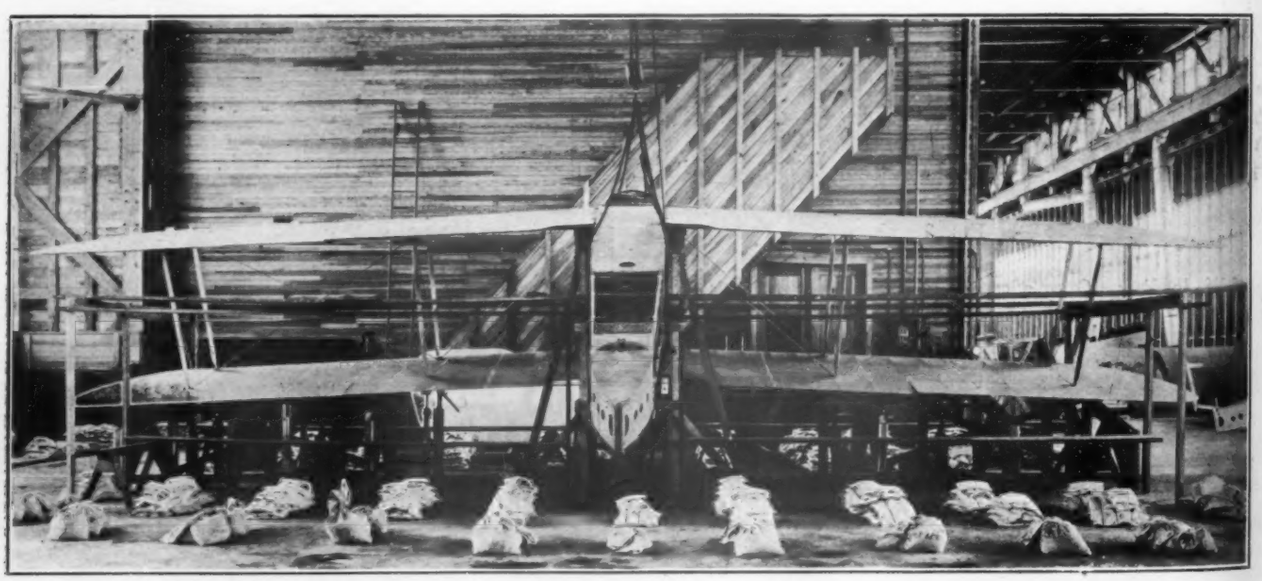


FIG. 7. ARRANGEMENT OF SUPPORTS AND SCAFFOLDING FOR SAND LOADING TEST

Distribution of Loading Between Two Wings of a Biplane

Accepted practice in France and England is as follows:

Gap/chord<1 sq. ft. of lower wing equivalent to .8 sq. ft. of upper surface.

Gap/chord>1 sq. ft. of lower wing equivalent to 1 sq. ft. of upper surface.

Distribution of Load Along the Chord of the Wings

The wing chord (Fig. 6) is divided into three parts: ⅓, ⅙, ½, with $\frac{W_n}{2}$ on front part, $\frac{W_n}{4}$ on middle part and $\frac{W_n}{4}$ on rear

part of wing. Toward the trailing edge of the wing no bags are placed, so that this loading gives the center of gravity of sand between ⅓ and ¼ of chord from leading edge.

Support of Wings and Scaffolding Sand Bags

The method of attaching the wings to the fuselage during test, the scaffolding for placing the sand bags on the wings and the supports for the jacks is clearly shown in Fig. 7 prior to the test. The wing truss has to be built up in testing as carefully as in preparing for flight. Trestles for preventing accidents on the final break are placed at intervals under the wings. Jacks for supporting the wings during loading are placed along the front and rear spars at the strut points and

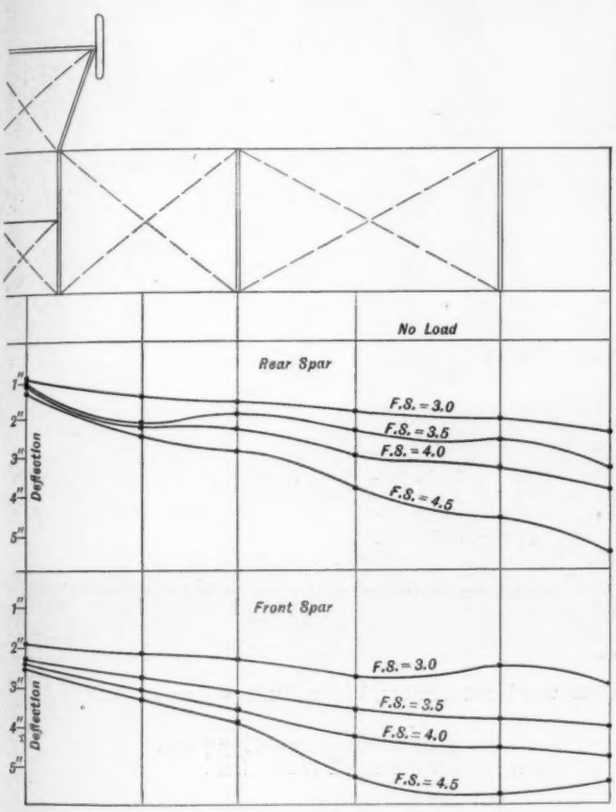


FIG. 8. DEFLECTION CURVES OF WINGS UNDER SAND LOAD TEST

in between. Vertical yard sticks have to be provided for measurement of deflections. Sand bags should be of varying weights, mostly 2, 5 and 10 lb., with some bags of 25 lb. Bags should be of flat section.

Prior to testing, sand bags are placed on the ground surrounding the plane in well-ordered fashion, as shown in Fig. 7. The wings are carefully marked off with strings to facilitate loading. Zero readings of vertical heights are taken at appropriate points. Jacks are then placed in position so as to just touch the wings and sand bags applied for the first factor of safety required, carefully and systematically. When the required load has been applied, the jacks are very carefully and slowly released and readings taken. The process is repeated until failure.

Many additional refinements may be introduced in conducting a sand test. By suspending a plumb bob from the top wing on sand test the retreat of the wing under the drag loads may be obtained and plotted. Tension meter readings on the cables and wires provide a great deal of interesting information. Sometimes before the test is carried on to destruction, the load is removed, and readings of permanent deflection taken. For measuring deflections, better methods than those of the simple yard stick are available. Thus wires may be stretched parallel to the wings, and distances from under the strut points measured rapidly to these wires. Each observer prefers a certain personal procedure in these details.

In Fig. 8, as an illustration, are shown typical deflection curves for different values of factor of safety.

Tests with Sand Load Placed on Upper Wing

In such tests, for which as mentioned previously it is very difficult to provide a satisfactory theoretical basis, it is customary to distribute a load equal to one-half that specified for the reversed wing truss test, the formula for loading becoming for any factor n

$$W_n^1 = \tfrac{1}{2}(W_g - W_w) - W_w.$$

The loading is so distributed by the French as to have the center of gravity about ¼ to ⅕ of the chord from the leading edge. The wing is again sloped to an inclination of 14 deg. or 25 deg. to the horizontal.

In all sand testing great care has to be exercised to prevent untoward accidents, such as the failure of a strut by premature bowing, or by the careless superposition of load causing a purely local failure. A test carefully carried out, besides giving merely the ultimate factor of safety, will also show up weaknesses in design, and generally serves as an object lesson. Considerable experience is required before the full value of a sand test can be obtained.

In conclusion, it may be said that a machine which has successfully withstood a sand test may possibly fail in the air, but will probably be strong enough, whereas a machine which has failed on sand test is certainly unsafe in the air.

Built-Up Beams and Struts

On account of the difficulty in securing suitable pieces for manufacturing the larger airplane parts, and the necessity of conserving material, several series of tests have been conducted at the Forest Products Laboratory at Madison, Wis., on built up beams and struts of various designs and also on various types of splices. Results of these tests were used in preparing Army and Navy specification for laminated and spliced beams and laminated struts. Two simple non-injurious methods for determining the strength of struts have been developed and further tested for inspection work, which it is thought will considerably reduce the number of rejections under the standard method.

The tests are made on full size specimens every strut used being subjected to the standard test which is more sure than any working load could possibly be.

Book Review

AEROPLANE CONSTRUCTION AND ASSEMBLY. By J. T. King and N. W. Leslie. (Press of Dunwoody Industrial Institute, Minneapolis, Minn. 115 pp. Many illustrations. $1.50.)

In their foreword the authors state that the purpose of this manual is to give aviation mechanics an essentially practical understanding of the work they will be expected to carry out —written by experienced and well-qualified men, who have, moreover, had the advantage of impartial, systematic instruction in the subject.

The little book carries out this purpose admirably. It begins with a very excellent nomenclature, fully illustrated by three-view cuts of an airplane. The most complete general instructions are given for the assembly of an airplane. The remarks on the care of the engine are brief but very much to the point.

The chapters dealing with airplane construction include most useful sketches of typical fittings, turn-buckles, splices, etc. A great many tips are given for remedying the defects of a machine as demonstrated in flight, such as tail-heaviness, nose-heaviness, etc.

The theory of flight is dealt with briefly, but with surprising exactitude for a book of this character.

Aeronautical Patents

ISSUED JANUARY 28, 1919

1,292,614—To John R. Killian, Detroit, Mich., Flying Machine.
1,292,662—To John B. Simmer and Richard W. Hicking, Worcester, Mass. Flying Machine.
1,292,415—To Peter Allinio, El Cerrito, California, Aeroplane.
1,292,596—To John R. Gammeter, Akron, Ohio, and Julius Bourguignon, Billancourt, France, assignors to the B. F. Goodrich Co. Stay-Fastener for Balloons.

The King 550 Hp. Aircraft Engine

The King 550 hp. aircraft engine, as illustrated in the accompanying photographs and drawings, was designed by Mr. Charles B. King, A. M. E., of the Bureau of Aircraft Production. The Aircraft Board authorized five of these engines to be built and tested.

The work was started at the plant of Brewster and Company, Long Island City, N. Y., and later all parts were shipped to McCook Field, Dayton, O., for final completion.

The engine is of an extremely interesting type, and its leading features may be enumerated as follows:

The engine will deliver from 500 to 600 hp. in flying service, at propeller speeds, varying from 1175 to 1435 r.p.m.

The engine may be installed in an airplane body adapted to the 12-cyl. Liberty engine. The King engine presents less head resistance and occupies less space. The added horsepower is, therefore, the result of carefully studied design.

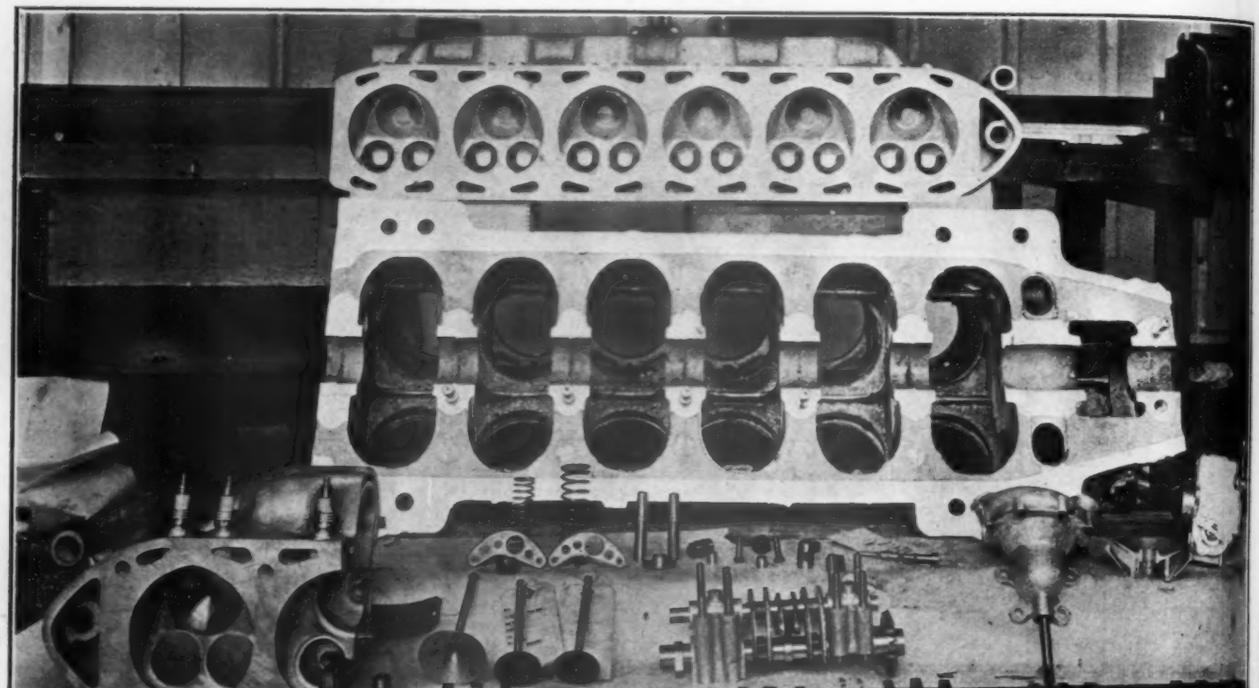


FIG. 1. CRANKCASE AND CYLINDER CASTINGS OF THE KING ENGINE, WITH VARIOUS PARTS

Characteristics

Twelve cylinders, fixed, water-cooled; six cylinders arranged in each bank of a 45 deg. V.
Bore, 5.5 in., 140 mm.
Stroke, 7 in., 178 mm.
Bore, stroke ratio, 1 to 1.273.
Engine displacement, 1995 cu. in.
Rated horsepower 550—at 1886 engine r.p.m., 1300 propeller r.p.m.
Area of one piston head, 23.75 sq. in.
Total piston area, 285 sq. in.
Compression ratio, 5 to 1.
Piston speed at rated hp., 2200 ft. per min.
Horsepower per cu. in. at rated hp., .276
M.e.p. at rated hp., 116 lb.
Crankshaft propeller gear ratio, 1.445 to 1 (18 to 26).
Weight of dry engine, 990 lb.
Weight of dry engine at rated horsepower, 1.8 lb. per hp.
Gas consumption, .50 to .54 lb. per hp./hr.
Oil consumption, .04 lb. to hp./hr.
Ignition, two independent magneto ignition systems.
Lubrication, pressure feed to all bearings.
Aluminum main casting.
Aluminum cylinder heads.
Removable cylinder liners.
Removable cylinder heads.
No exposed working parts.
Accessibility of adjustable working parts.
No exposed water or oil connections.

Construction

The main casting of the engine is of aluminum and presents a firm engine structure into which fit the cylinders. The crankshaft is mounted in the base of this casting by means of eight bearings.

The cylinder heads, which are also of aluminum, are shown in detail in the longitudinal and end cross section views of the engine. Each cylinder head casting forms the combustion chamber for six cylinders. Three valves per cylinder are mounted in the head; each cylinder head carries an overhead camshaft and rocker arms.

The camshafts are driven by a set of bevel gears and shafts, mounted on the rear of the main engine casting and enclosed by a rear cover, which mounts the magnetos. The carbureters are also mounted under the magnetos and connect by means of two manifolds to two cylinder heads.

The cylinder liners are aluminum castings, machined inside and out and have a cast iron liner .0627 in. in wall thickness. Before inserting these cast iron liners in the aluminum barrels, the barrels are expanded by hot water and the liners are then pressed into place. The method of securing the cylinders in the main casting is shown in Fig. 3. Cork packing is used to make the water tight joint at the lower end of the cylinder barrel. A copper and asbestos gasket is placed under the upper shoulder of each cylinder liner. A conventional copper and asbestos gasket is placed between each cylinder head and the main engine casting.

Each cylinder head is fitted with a cover, Figs. 2 and 3, which

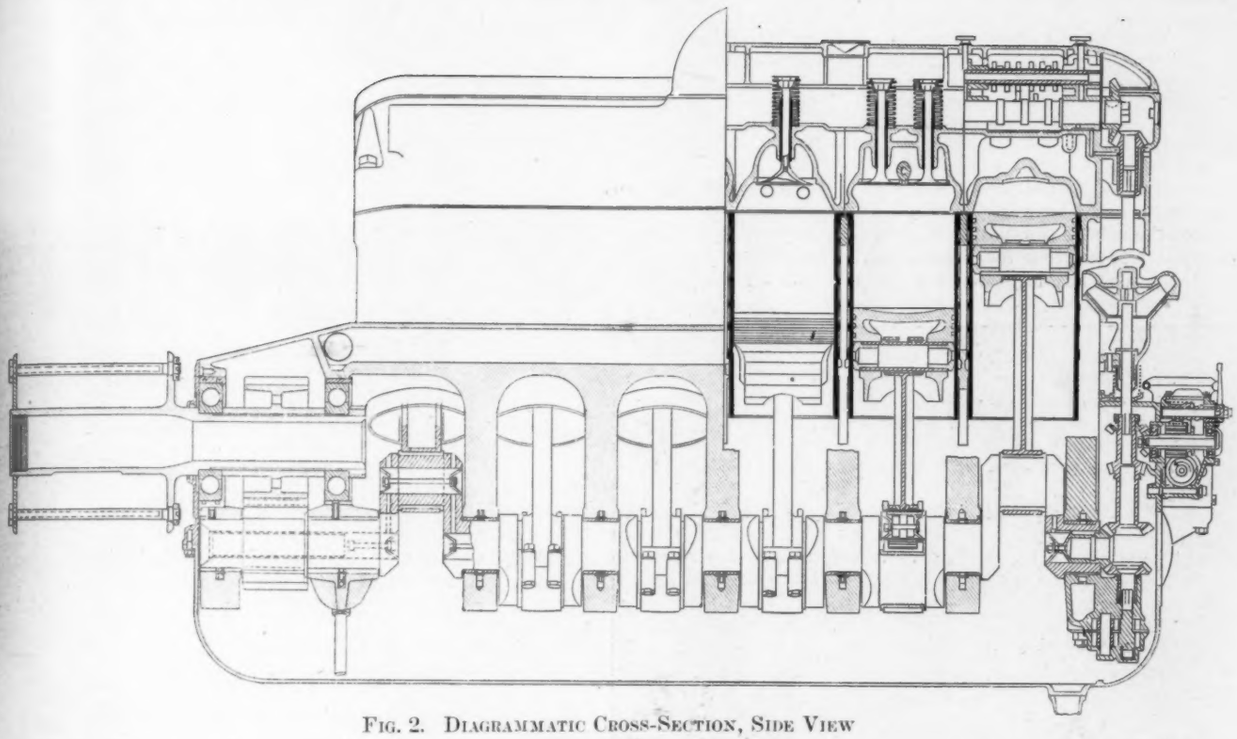


FIG. 2. DIAGRAMMATIC CROSS-SECTION, SIDE VIEW

may be removed and the clearance between the rocker arms and the valves adjusted. The roller, which rides on the valve stem, has an adjustable eccentric in the rocker arm. Valve stems, rocker arms, camshafts, etc., are oiled thoroughly in the enclosed housings.

The pan of the engine is an aluminum casting. It contains no pump, as this is part of the rear main bearing cap. Provision is made to keep the pan dry from oil under all conditions of flight, climbing, driving, etc.

The propeller nose is strongly ribbed in the interior, and the front of this nose is covered by a steel plate.

Pistons

The pistons are of aluminum, and of the ribless design and of the slipper type. Five piston rings are used, all above, as a scraper ring in the lowest groove. This ring is beveled toward the top, giving a greater wall pressure per square inch, thereby cutting the oil, which is disposed of through a circum-

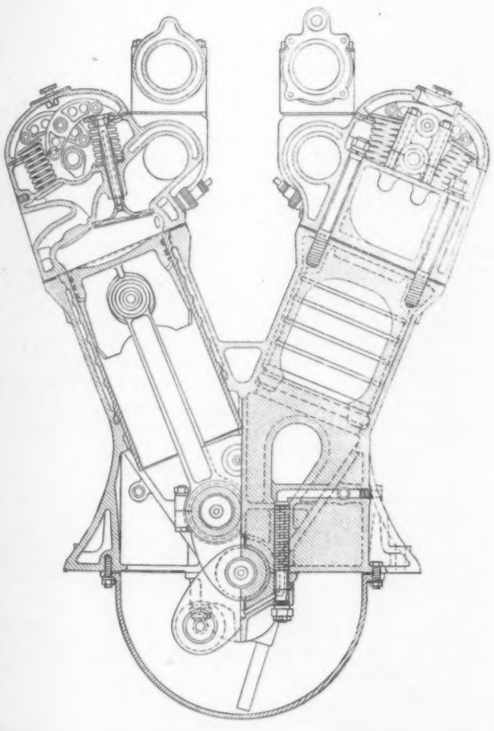


FIG. 3. DIAGRAMMATIC CROSS-SECTION, END VIEW

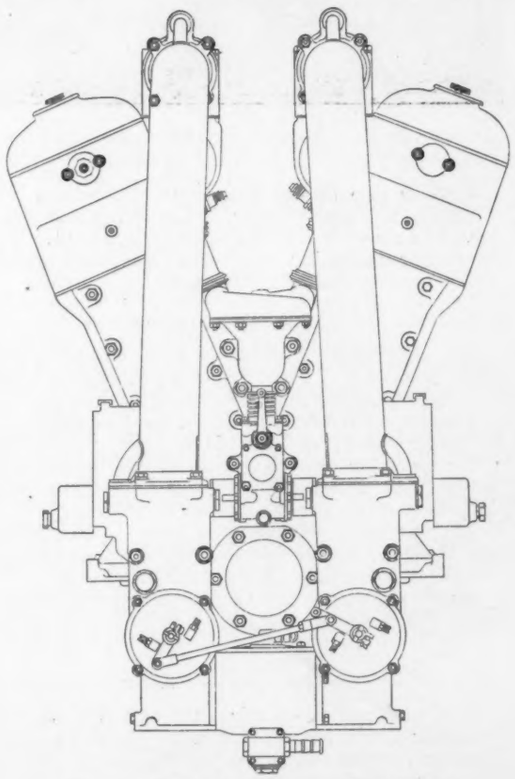


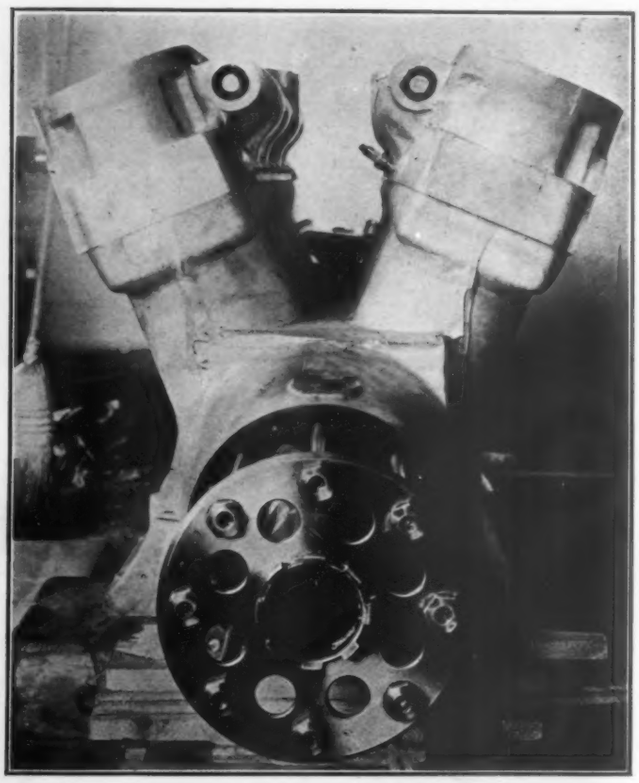
FIG. 4. OUTLINE DRAWING, END VIEW

ferential recess and thence through drilled holes, to the inside of the piston.

The wrist pin is of the floating type, with aluminum end plugs. Outside diameter 1.562 in., inside diameter 1.281 in. Overall length, 4.687 in.

Connecting Rods

The connecting rods are of the articulated type, in which the smaller or articulated rod, big end bearing is carried by the master rod. The articulated pin is 30 deg. from the center line of the master rod and is supported on tapered split rings, clamped into lugs on the master rod. The pin supports are hardened steel bushing on which the articulated rod operates,



PROPELLER END VIEW OF THE ENGINE CASTINGS ASSEMBLED

and which also acts as a spacer for the lugs. The bearing medium is a bronze bushing, acting on the hardened steel bushing. The rods are of the I-beam type section. The length of the master connecting rod from center to center is 12 in. The ratio of the rod length to the stroke is 1.715 to 1.

Crankshaft and Bearings

The crankshaft is of the conventional six throw 120 deg. type. Diameter of crank pin bearings $2\frac{5}{8}$ in. Length $2\frac{1}{2}$ in. The crank pins are bored out, the inside diameter being $1\frac{3}{8}$ in.

The main crankshaft bearings, eight in number, are $2\frac{5}{8}$ in. in diameter and 2 in. long. Main bearing No. 7, near the propeller reduction gear, is $3\frac{7}{8}$ in. long. The main bearings are bored out to inside diameter of $1\frac{3}{8}$ in. The rear bearing is drilled out to an inside diameter of $1\frac{5}{8}$ in.

The aluminum bearing caps are designed for light weight and strength, and are supported from the main engine structure by steel studs and nuts.

As oil pressure is maintained in the crankshaft, steel cones are arranged to make oil tight chambers in the hollow bearings of the shaft. These may be removed for cleaning,

Propeller Shaft and Reduction Gears

The construction of this part of the engine may be best understood by reference to Fig. 3. The ball bearings are combination annular and thrust bearings, as first introduced in the King-Bugatti engine.

The thrust of the propeller in either direction is taken by the front ball bearing, which is clamped between the steel nose plate and the main casting.

The reduction gears have a tooth face of $3\frac{1}{2}$ in. in width.

Valves and Mechanism

There are three valves per cylinder, one inlet valve with a clear diameter opening of 3 in. and a lift of $\frac{9}{16}$ in. Two exhaust valves, with a clear diameter opening of $2\frac{1}{16}$ in. and a lift of $\frac{7}{16}$ in.

The inlet valve seat is at an angle of 10 deg., the exhaust valve seat at an angle of 45 deg. The valve seats are pressed into the aluminum cylinder seats and are of a high chromium material.

Rocker arm ratio 1.5 to 2.25 or 1.5.

INLET VALVE AND CAM

Inlet cam lift, .396, or a little more than 25/64.

Inlet valve lift 19/32 (valves 3 in. clear D).

Inlet valve seat angle 10 deg. (cos. equals .9848).

Inlet valve lift area equals $3 \times 11 \times 19/32 \times .9848 = 5.51$ sq. in.

EXHAUST VALVE AND CAM

Exhaust cam lift .334.

Exhaust valve lift (2 valves $2\frac{1}{16}$D.) equals $\frac{1}{2}$ in.

Exhaust valve seat angle 30 deg. (Cos. equals .866).

Exhaust valve lift area equals $2\frac{1}{16} \times 11 \times \frac{1}{2} \times .866 \times 2 = 5.625$ sq. in.

Gas Passages and Valve Ports

INLET VALVE GAS VELOCITY COMPUTATION

Inlet valve 3 in. clear diameter having 19/32 (.5937) lift and 10 deg. seat angle.

Inlet valve port area, 5.51 sq. in.

Gas velocity through inlet valve,

$$\frac{2200 \times 23.76}{5.51} = 9500 \text{ ft. min., or } 158.3 \text{ ft. sec.}$$

EXHAUST VALVE GAS VELOCITY COMPUTATION

Exhaust valves $2\frac{1}{16}$ in. clear diameter having $\frac{1}{2}$ (.500) lift and 30 deg. set angle.

Exhaust valve port area, 5.625 sq. in.

Gas velocity through exhaust valves equals

$$\frac{2200 \times 23.76}{5.625} = 9.300 \text{ ft. min., or } 155 \text{ ft. sec.}$$

Carburetor System

A special King designed carbureter is used with one common float chamber for both Venturis. Barrel throttles and proper water jacketing are features shown in Fig. 3.

Ignition

Two spark plugs are provided per cylinder and two magnetos are provided, each one of which fires the entire engine. The engine fires 45 deg. and 75 deg., as measured on the crankshaft. Dixie magnetos running at $1\frac{1}{2}$ crankshaft speed and delivering four impulses per revolution of the armature, provide high tension current direct from a gap distributer mounted on the magneto to the cylinders of the engine. As it was desired to have an advance and retard ignition angle of 45 deg., and this under the control of the operator, a special magneto drive is built in the King engine, which enables the operator to change the timing relation of the magneto to the engine throughout this angle without, however, disturbing the internal timing of the magneto, and thus without affecting the intensity of the magneto impulses. As can be seen in Fig. 2, flexible spring couplings are provided between this drive and each magneto. These couplings are also adjustable, so that the magnetos may be timed to the engine without removing them.

A starting magneto is arranged to provide current to the proper cylinder, by way of a regular magneto distributer for starting the engine from a standstill.

Lubrication System

A high pressure oiling system is used, the normal running pressure being 45 lb./sq. in. The pump is of the gear type,

there being a scavenging and a pressure pump located in one housing and bolted to the rear main bearing cap, one pump being located above the other and being driven off the same shaft by bevel gears from the crankshaft.

From the pressure pump the oil is led through drilled holes to the main pressure line. A pipe cast in the crankcase, from which drilled holes lead to the main bearing studs, passing through the hollow bearing studs, the oil is conducted to the bearing caps, thence to the main bearings and through drilled holes to the crank pins, each crank pin being supplied from two main bearings. Oil is retained in the hollow crank pins and main bearings by means of cone shaped plugs.

A relief valve is located at the front of the main pressure line in such a way that all surplus oil is thrown between the reduction gears.

Two branch pipes lead from the main pressure line, one to each cylinder head where the oil is carried through the rocker arm supporting shaft and distributed through holes to each rocker arm and camshaft bearing, the overflow oil returning to the crankcase through the camshaft driveshaft housing and lubricating the timing gears.

The scavening pump draws oil from the front or propeller end of the crankcase and delivers it to the oil tank, which is not a part of the engine. Another pipe leads from the rear of the crankcase to the oil tank. The oil flows through this pipe by gravity to the oil tank.

This system was first used by Mr. King, in the King-Bugatti engine, with satisfactory results.

It can readily be seen that with the engine used as a tractor in a plane and going into a nose dive, the oil will be sucked from the propeller end and forced to the oil tank, whereas in a climb the oil will flow by gravity from the rear of the crankcase to the oil tank, which is located behind the engine.

One of the features is the absence of all detachable oil piping, as all oil passages are either cast in or machined into the various parts, making it impossible for any oil connection to become loosened during the running of an engine or omitted in assembly.

Limiting Power of a Single Engine

By Edward P. Warner

Ever since the first feeble beginnings of airplane design, when machines were equipped with engines which developed less power than does a single cylinder of the Liberty, and when Lieut. Dunne's experiments were discouraged by the British government because the 50-hp. engine which he desired to employ was considered so large as to be wholly impracticable, the tendency has been toward an increase in power. This tendency has manifested itself by an increase in cylinder dimensions, by an increase in volumetric efficiency and mean effective pressure, by an increase in the number of cylinders in a single engine, and, during the last two or three years, by the trend toward a multiplicity of power plants for large machines.

While it is probable that a trend in the reverse direction will now set in, and that the demand from sportsmen will be for a small machine with a low-powered engine involving only a relatively small first cost and low expense for maintenance, at the same time the demand for large engines, and many of them will be kept up by the construction of passenger and mail-carrying airplanes of enormous size.

A limiting factor for the maximum size of a single power unit of any type is the stress in the propeller. It can readily be shown that propeller stresses of all types depend only on the tip speed, so that the total stress in a 6-ft. propeller turning 2000 r.p.m. will be the same as in a geometrically similar propeller 12 ft. in diameter and turning 1000 r.p.m. The highest tip, or peripheral, speeds that it has been found possible to employ with a reasonable factor of safety range from 45,000 to 55,000 ft. per min., and it is very improbable that it will be considered safe to much exceed the second of these figures at any time in the future, either in wood or metal propellers. With a 9-ft. propeller turning 1700 r.p.m. on the Liberty the peripheral speed is 48,000 ft. per min. If the propeller were run in a vacuum, so that bending did not appear at all, the peripheral speed of a wooden propeller could be run up to about 80,000 ft. per min. without causing the stress in the wood to rise above 2500 lb. per sq. in., but the bending moments due to air pressure increase the stresses so that it is not safe to approach anywhere near this figure.

I have shown in a previous article that we can write for propellers of ordinary type:

$$P = \frac{K_1 K_2 D^2 B N^2 n V}{10^{10}}$$

where P = horsepower absorbed
D = diameter of propeller (ft.)
B = maximum blade width (in.)
N = r.p.m. of propeller
n = number of blades
V = speed of flight (m.p.h.)

K_1 and K_2 are arbitrary constants depending on the shape of the blade, etc., and their product lies, in almost every case, between .65 and .88.

The above equation can be written in the form:

$$P = \frac{K_1 K_2 \left(\frac{B}{D}\right) . (ND)^2 n V}{N^2 \times 10^{10}}$$

If we take 55,000 ft. per min. as the limiting value of the peripheral speed, we shall have: $ND = 17{,}500$. Substituting this value in the equation, and substituting .88 for $K_1 K_2$ and 1.2 for $\frac{B}{D}$ (since B is measured in inches and D in feet, and the maximum blade width is never likely to be more than one-tenth of the diameter), the equation reduces to the form:

$$P = nV \times \frac{10{,}000{,}000}{N^2}$$

In order to keep the peripheral speed within safe limits, therefore, the value of $\frac{P \times N^2}{V}$ must not exceed 20,000,000 for a two-bladed, and 40,000,000 for a four-bladed, propeller. To be on the safe side, the peripheral speed should be a little lower with four blades than with two, and the maximum blade width for a four-blader is also likely to be quite a little less than that for a two-bladed screw of like diameter, so it will be well to take 36,000,000 as the limiting value with four blades.

It should be remembered that these are absolute limits, which are not likely to be exceeded at any time in the future, and that they are considerably higher than present practice. At present it would hardly be considered safe to design a two-bladed propeller for a higher value of $\frac{P \times N^2}{V}$ than 14,000,000.

It is evident from this formula that we can absorb a very large power on a single propeller if we gear it down to a low enough number of revolutions per minute. If we take 14,000,000 as our limiting value, assuming that no improvement on present practise in this respect is possible, we shall be able to absorb 547 hp. with a two-bladed propeller turning 1600 r.p.m. and a flight speed of 100 m.p.h. If, however, we gear the propeller down to 1000 r.p.m., we shall increase the diameter for a given power consumption only about 28 per cent, and shall raise the capacity to 1400 hp. With a four-bladed propeller it would be easy to take 2400 hp. without the stresses becoming in any way excessive. Gearing down to 800 r.p.m., and using a propeller about 20 ft. in diameter, the capacity is increased to approximately 4000 hp.

It appears, then, that it will be possible to take any power within reason on a single propeller, and that in no engines of sizes now projected or likely to be projected in the near future will it be necessary to revert to the Wrights' original practise of distributing the power of a single engine to two propellers. The extremely high rotational speeds of the present-day designs must be abandoned, however, as they are prejudicial alike to safety and to efficiency.

The Thomas-Morse Single and Two-Seater Airplanes

Prior to our entrance in the war the Thomas-Morse Aircraft Corp., of Ithaca, N. Y., was engaged in building a number of training seaplanes for the Navy Department, and airplane engines for both the Army and the Navy. At about this time an experimental single-seater scout, the type S-4, fitted with a 100-hp. Monosoupape Gnôme engine, was developed for the consideration of the War and Navy Departments; this machine was so designed that either a land under-carriage or floats could be fitted.

THOMAS-MORSE MB-3 SINGLE-SEATER FIGHTER

Tests carried out with the S-4 at the Government experimental air station at Hampton, Va., gave so promising results that, with some changes suggested by these tests, an order for fifty machines of an improved type, the S-4B, was given by the War Department shortly after the United States entered the war. This order was later increased to 150 to take care of the growing need for a single-seater training machine for fighting pilots.

In the meantime a similar machine, fitted with twin floats, was developed for naval service, and resulted in a small order from the Navy Department. This is the type S-5.

With steadily increasing production of the land type additional orders were placed by the War Department, and an 80-hp. Le Rhone engine, manufactured in this country by the Union Switch and Signal Co., of Swissvale, Pa., was then substituted for the Monosoupape Gnome. The manufacture of this type, officially known as the S-4C, was placed in production, and quantities shipped to nearly every Army flying field in the country, where they constituted the bulk of our single-seater advanced training airplanes. In the famous flight of 260 airplanes from Rockwell Field, San Diego, Cal., to San Francisco and back fully one-half of the machines were Thomas scouts.

Type S-4C Single-Seater

While primarily designed for advanced training, the Thomas-Morse S-4C is also well suited for sport purposes, because its small size and low wing loading, combined with a generous size of the control surfaces, gives the pilot a machine which is easily controlled and maneuvered. The specifications of the S-4C are as follows:

General Dimensions—Span, 26 ft. 6 in.; length, overall, 19 ft. 10 in.; height, 8 ft. 1 in.

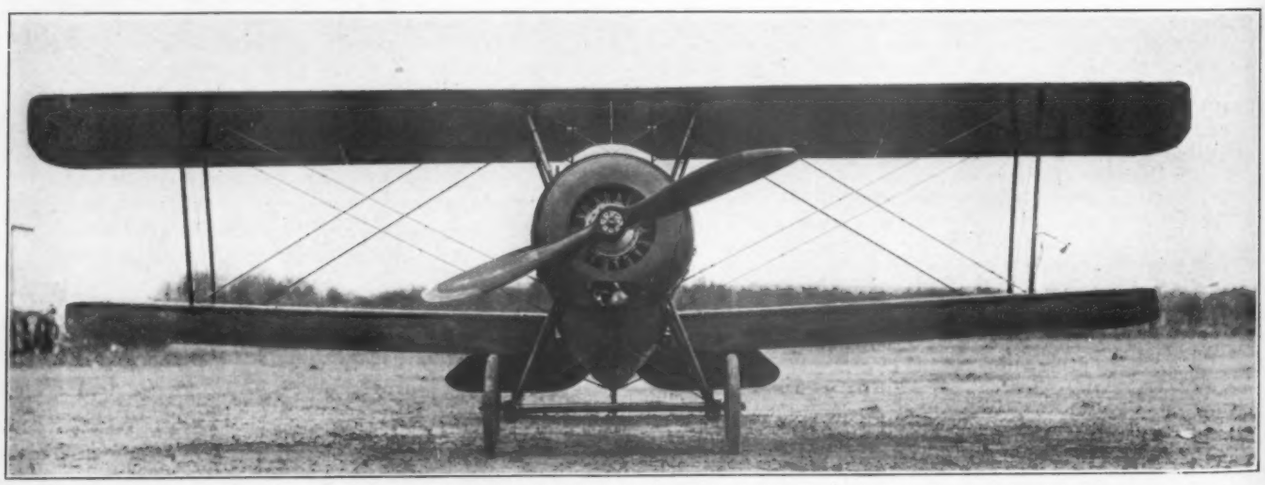
Weight and Lift Data—Gross weight, 1,330 lb.; wing area, 234 sq. ft.; wing loading, 5.7 lb. sq. ft.; horsepower required, 90; power loading, 14.8 lb. hp.

Power Plant—Engine, 80 hp. Le Rhone; engine speed, 1,250 r.p.m.; fuel capacity, 30 gal., sufficient for 3¾ hr. flight at full power; oil capacity, 6 gal., sufficient for 4½ hr. flight at full power. Airscrew, 2-bladed tractor, 8 ft. diameter.

Undercarriage—Two-wheel V-type; tread, 5 ft.; tires, 26 x 3 in.

Area of Control Surfaces—Ailerons, 25 sq. ft.; elevators, 16.8 sq. ft.; rudder, 8.5 sq. ft.; horizontal fin, 16.8 sq. ft.; vertical fin, 3.5 sq. ft.

Performance—High speed, 97 m.p.h.; low speed, 45 m.p.h.; initial climb, 7,500 ft. in 10 min.



THOMAS-MORSE S-4C ADVANCED TRAINING MACHINE

Type S-4E Single-Seater

This machine, while similar in general appearance to the one just described, is 180 lb. lighter and has a much smaller wing area, which is obtained by a reduction of the dimensions and the use of tapering wings. With the same engine this machine thus puts up a much better performance and possesses remarkable maneuvering qualities, requiring only a slight effort on the pilot's part to do all sorts of aerobatics. The S-4E is therefore particularly adapted for exhibition work, where the utmost in performance and maneuverability

is desired. The characteristics of the machine are as follows:

General Dimensions—Span, 22 ft. 6 in.; length, overall, 19 ft. 4 in.; height, 7 ft.

Weight and Lift Data—Gross weight, 1,150 lb.; wing area, 145 sq. ft.; wing loading, 8 lb. sq ft.; horsepower required, 90; power loading, 12.8 lb. hp.

Power Plant—Engine, 80 hp. Le Rhone; engine speed, 1,250 r.p.m.; fuel capacity, 20 gal., sufficient for 2½ hr. flight at full power; oil capacity, 6.5 gal., sufficient for 3½ hr. flight; airscrew, 2-bladed tractor, 7 ft. 6 in. diameter.

Undercarriage—Same as Type S-4C.

Area of Control Surfaces—Ailerons, 16.4 sq. ft.; elevators, 16.8 sq. ft.; rudder, 7.3 sq. ft.; horizontal fin, 11.2 sq. ft.; vertical fin, 3.8 sq. ft.

Performance— High speed, 112 m.p.h.; low speed, 55 m.p.h. initial climb, 8,500 ft. in 10 min.

Type S-6 Two-Seater

The Thomas-Morse Type S-6 is a tandem two-seater tractor biplane which answers the purpose of providing a slow-landing machine for training purposes or civilian use. Its design follows the general lines of the Type S-4C, with such modifications as are necessary to accommodate a passenger. The wing area has been increased, and minor changes made with a view to reducing the gross weight, without, however, changing the factor of safety. Dual control is fitted, with flexible connections in the passenger cockpit so that the pilot may maintain control at all times. The specifications of the S-6 are as follows:

General Dimensions—Span, 29 ft.; length, overall, 20 ft. 8 in.; height, 8 ft. 10 in.

Weight and Lift Data—Gross weight, 1,385 lb. Wing area, 296 sq. ft.; wing loading, 4.68 lb. sq. ft.; horsepower required, 90; power loading, 15.4 lb. hp.

Power Plant—Engine, 80 hp. Le Rhone; engine speed, 1,250 r.p.m.; fuel capacity, 20 gal., sufficient for 2½ hr. flight at full power; oil capacity, 4 gal., sufficient for 3 hr. flight at full power; airscrew, 2-bladed tractor, 7 ft. 10 in. diameter.

Undercarriage—Same as above.

Area of Control Surfaces—Ailerons (four), 31.5 sq. ft.; elevators, 16.8 sq. ft.; rudder, 8.5 sq. ft.; horizontal fin, 14.5 sq. ft.; vertical fin, 3.5 sq. ft.

Performance—High speed, 105 m.p.h.; low speed, 40 m.p.h. initial climb, 8,000 ft. in 10 min.

Type S-7 Two-Seater

To meet the demand for side-by-side seating, an entirely new machine is now ready for those desiring this arrangement in the Type S-7. This has been designed particularly for civilian use, attention having been directed to providing comfortable accommodations. The specifications of the S-7 are as follows:

General Dimensions—Span, 32 ft.; length, overall, 21 ft. 6 in.; height, 9 ft.

Weight and Lift Data—Gross weight, 1,480 lb. Wing area, 322 sq. ft. Wing loading, 4.6 lb./sq. ft. Horsepower required, 90. Power loading, 16.5 lb. hp.

Power Plant—Engine, 80 hp. Le Rhone. Engine speed, 1,250 r.p.m. Fuel capacity, 20 gal., sufficient for 2½ hr. flight at full speed. Oil capacity, 4 gal., sufficient for 3 hr. flight at full speed. Airscrew, 2-bladed tractor, 8 ft. diameter.

Undercarriage—Same as above.

Area of Control Surfaces—Ailerons, 40 sq. ft. Elevators, 16.8 sq. ft. Rudder, 8.5 sq. ft. Horizontal fin, 14.5 sq. ft. Vertical fin, 3.6 sq. ft.

Performance—High speed, 90 m.p.h. Low speed, 40 m.p.h. Initial climb, 6,700 ft. in 10 min.

Type S-5 Seaplane

The Type S-5 seaplane is, as has been mentioned before, in effect a S-4C fitted with twin floats. However, on account of the additional weight of the floating system, the wing area has been somewhat increased, while a 100 hp. Monosoupape Gnôme has been substituted for the Le Rhone engine. The S-5 is the only single-seater advanced training seaplane used by the Naval Flying Corps; its specifications are as follows:

THOMAS-MORSE S-6 TANDEM-SEATER

General Dimensions—Span, 26 ft. 6 in. Length, overall, 22 ft. 9 in. Height, 9 ft 7 in.

Weight and Lift Data—Gross weight, 1,500 lb. Wing area, 240 sq. ft. Wing loading, 6.25 lb./sq. ft. Horsepower required, 105. Power loading, 14.3 lb./sq. ft.

Power Plant—Engine, 100 hp. Monosoupape Gnôme. Engine speed, 1,250 r.p.m. Fuel capacity, 30 gal., sufficient for 3 hr. flight at full power. Oil capacity, 6.5 gal., sufficient for 3½ hr. flight at full power. Airscrew, 2-bladed tractor, 8 ft. diameter.

Undercarriage—Twin floats and tail float.

Area of Control Surfaces—Ailerons (two), 30 sq. ft. Elevators, 22 sq. ft. Rudder, 8.5 sq. ft. Horizontal fin, 16.8 sq. ft. Vertical fin, 3.5 sq. ft.

Performance—High speed, 95 m.p.h. Low speed, 50 m.p.h. Initial climb, 5,200 ft. in 10 min.

Type MB-3 Pursuit Machine

Towards the close of the war the Experimental Department of the Thomas-Morse Aircraft Corp. set to work on the design of a two-seater fighter fitted with the Liberty-12 engine; two types of which, the MB-1 and MB-2, were built. In addition a single-seater fighter, or pursuit machine, fitted with the 300 hp. Hispano-Suiza engine, the MB-3, was developed. The conclusion of hostilities, by the signing of the armistice, prevented the early completion of these fighting machines for service at the front.

The MB-3 single-seater-fighter has the distinction of being

the fastest American machine in existence at the date of writing, its high speed being 163.68 m.p.h. For this purpose every effort has been made to provide the most effective streamlining throughout this machine; the bracing wires are all of streamline section. The body is of conventional construction, with the exception of tie-rods replacing piano-wires and turnbuckles. The engine section is built up almost entirely of three-ply, the engine bearers and supports being of this construction, which is exceedingly light for the requisite strength. The forward portion of the body is of partial streamline section, which is further enhanced by a streamline nose ending with the airscrew. At the pilot's compartment conventional rectangular construction or particularly deep section is used.

Ailerons are fitted to the upper wings only; the radiator is disposed in the upper wing. The specifications of the MB-3 are as follows:

General Dimensions—Span, 26 ft. Chord, 5 ft. 3 in. Length, 19 ft.

Weight and Lift Data—Gross weight, 2,050 lb. Wing area, 250 sq. ft. Wing loading, 8 lb./sq. ft. Horsepower required, 340. Power loading, 6 lb. hp.

Power Plant—Engine, Hispano-Suiza model H; 340 hp. at 1,900 r.p.m. Fuel capacity, sufficient for 3 hr. at full power, at 10,000 ft.

Performance—High speed, 163.68 m.p.h. Initial climb, 1,000 ft. in 20 sec.; 10,000 ft. in 4 min. 52 sec.

The above performance was made during preliminary tests carried out by Pilot Frank H. Burnside at Ithaca, N. Y., in which full load was carried with the exception of 170 lb. of military load.

Armament—Two Browning machine guns, synchronized with the airscrew, and 1,500 rounds of ammunition.

The Edstrom Wire Wrapping Machine

The Edstrom Wire Wrapping Machine was set up and demonstrated, November 16 to 20, 1918, at McCook Field, Dayton, Ohio, where the finished test specimens were tested a few weeks later. The following report made to the Technical Division of the Air Service is based on these tests:

Description

Figure 1 shows the wire wrapping machine which was built by the Edstrom-Olston Machinery Co., of Chicago. The

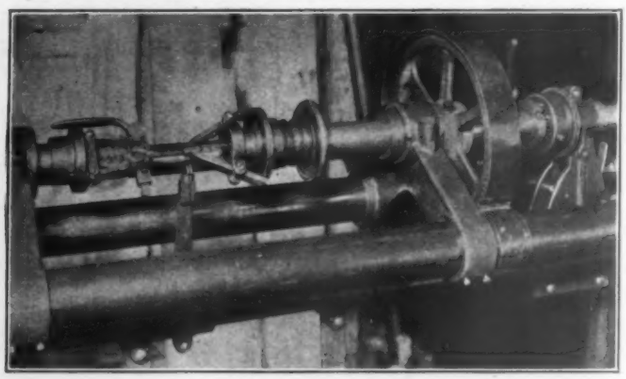


FIG. 1

legs were attached to the temporary wooden base to facilitate frequent handling and shipment between demonstrations.

The first operation in making the cable terminal is to form the loop. For this purpose there is a special bending fixture attached to the rear of the machine. This is partly visible at the extreme left end of Fig. 1. The cable is placed between pins, one of which is mounted on a swinging lever. By a quick movement of the lever, the cable is bent to the proper form. A formed loop is shown in illustration, mounted on a board which rests on the machine. Two turns of soft wire can be noticed on the end of the cable. These are always added before cutting a cable to keep the wires from untwisting. They are automatically ejected when the wrapping is nearly completed.

After the loop has been formed in the end of the cable, the thimble is inserted and the end of the cable is gripped firmly in the jaws of the machine. The rest of the cable extends through the rear center and long tube on the right. The serving wire is led from a spool mounted on the under side of the machine around a drum and through the serving guide. By adjustment the wire can be wrapped at any desired tension.

Ordinarily a shackle or turnbuckle would be attached to the terminal loop while being wrapped. This was not done in the case of the specimens made for test purposes, but it is essential that the jaws and headstock be able to accommodate any such fitting that is to be attached permanently to the terminal.

The machine is driven by a motor which is fitted to the base. The head and tail centers are geared together and turn simultaneously. The tail center and feeding guide travel laterally at a speed sufficient to wind the wire as close as desired. This lateral motion is adjusted by a set of change gears. Means is also provided for automatically leaving a space in the winding.

Test Specimens and Results of Tests

Tables I and II give complete data, including the description, important dimensions and strength of the various specimens tested.

All specimens were of 19 wire non-flexible Roebling steel cable. The total length of each specimen was about 26 inches. Tensile tests were made in the regular manner on an Olsen testing machine, the head of the machine moving uniformly at a speed of .10 in. per minute.

The Bureau of Aircraft Production Specification No. 25513-A for the Manufacture of Wrapped Terminals for Cables states in detail the approved methods of making terminals in airplane cable. Table III gives the tabulated dimensions of the wrapping wire copied from the above specification. The use of soft annealed steel wire thoroughly tinned is required. Stearic acid or a rosin solution is specified for the flux. The solder is approximately 45 per cent tin and 55 per cent lead. The terminals may be pre-soldered before wrapping or dip soldered after wrapping, but in any case the use of hand soldering copper is specified for finishing.

It will be noticed that the test specimens were made up somewhat different from the way the specification allows. The serving wire was either copper or untinned annealed steel and the served length on all specimens was longer than standard. It is, therefore, probable that the strengths of the unsoldered specimens were greater than they would have been had the serving wire been tinned steel wire of the dimensions shown in Fig. 2. The results of these and other tests however, conclusively show the advantages to be obtained by the use of a machine for wrapping the serving wire, both as to the increased speed with which the operation can be performed and the strength of the wrapped but unsoldered terminal. The stronger the unsoldered terminal, the less is the necessary dependence upon the strength of the solder. It is to be noted that of the ten unsoldered specimens sizes ⅛ in. to 5/32 in., only one failed at a load below the rated capacity of the cable. The 3/16 in. specimens served with copper wire failed at loads averaging 71 per cent of the full strength of the cable. A previous test (S. T. No. 98) on some 3/16 unsoldered handwound terminals received from the Curtiss Aeroplane Corp. showed an average strength equal to 32 per cent of the cable strength. Other Curtiss specimens identical except that they were machine-wound showed an average strength of 52 per cent.

When cable terminals are made in quantities the use of a machine for wrapping is a great time saver. By the hand method ⅛ in. terminals can be completely finished at the rate of about 12 to 15 per hour, 3/16 terminals at the rate of about 9 to 11 per hour. By using the machine for wrapping, the rate is easily 30 per hour for the ⅛ to 3/16 sizes.

It was believed that due to the tightness of the machine

wrapping a 100 per cent efficient terminal might be obtained by merely dip soldering the wrapped terminal without subsequent use of the hand soldering operation. For this reason, some specimens of each size were dip soldered only. In every case these terminals proved 100 per cent efficient, failure always occurring in the cable, although considerable distortion in the terminals was common. However the appearance of the joints when merely dip soldered was not very satisfactory and not such as to inspire confidence in their strength. The solder did not properly fill in between the wrapping wires except at local points. Severe shock or vibration might weaken such joints.

A large number of specimens were wrapped with a slight space between each turn of the wire. This is contrary to our regular practice but has been suggested as a means for producing a safer joint when thoroughly soldered. The English have criticized our closely wrapped terminal although examination by unwrapping the wire has usually shown the solder to be well distributed beneath. When a space is left between turns it is not necessary to unwrap the wire to make sure that the solder is thoroughly distributed.

TABLE I. TEST DATA

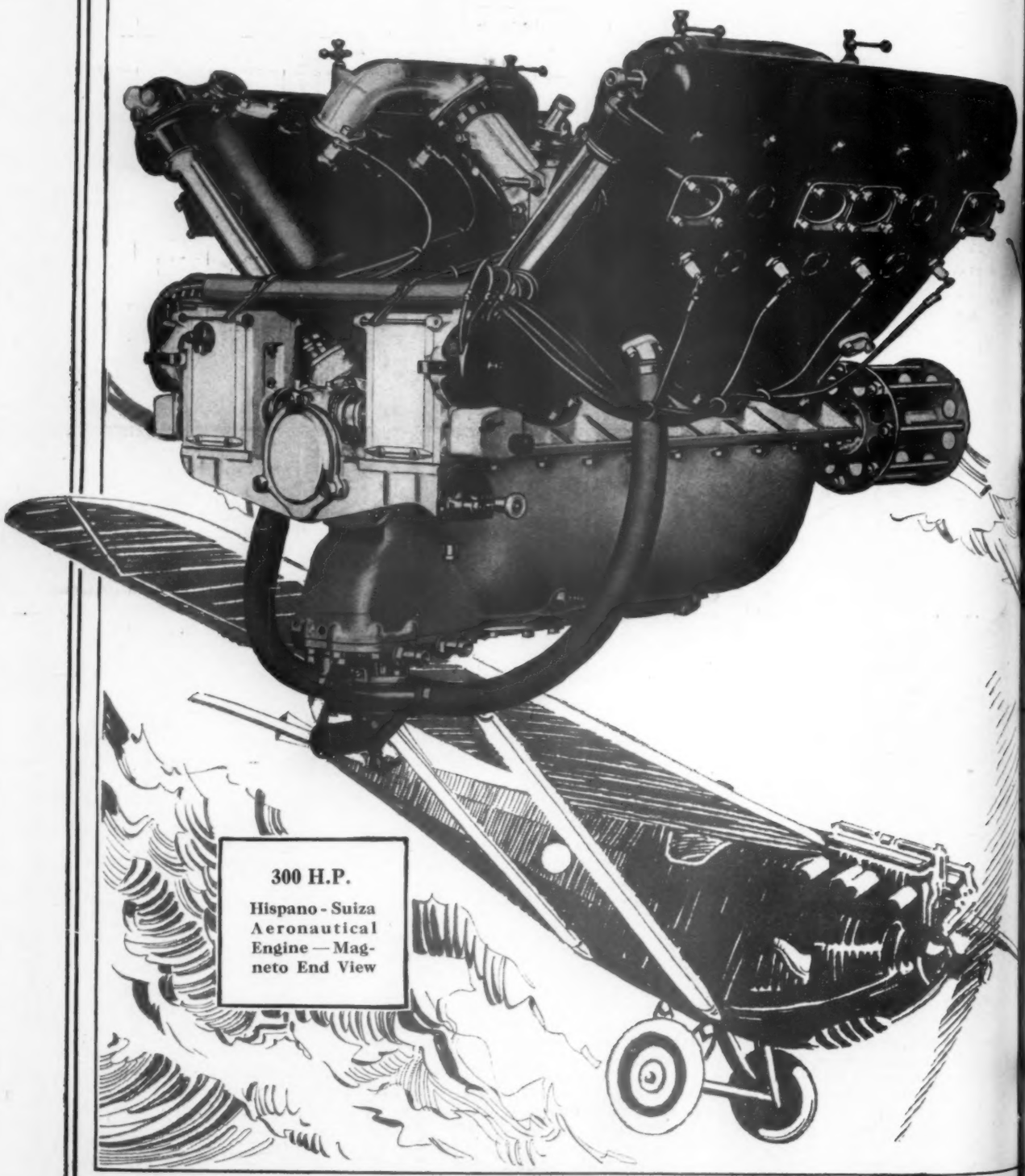
Specifications	How Soldered	Nominal Diameter	Actual Diameter	Serving Wire		How Served	See Fig. 2		Rated Strength	Maximum Load	Type of Failure
				Kind	Diameter		L	L			
1	None	1/16	.123	Copper	.028	Open	4 1/4	4	2100	2400	Cable
2	"	1/16	.123	"	.028	"	4	3 3/4	2100	1430	Terminal
3	"	1/16	.124	"	.028	"	4 3/4	4	2100	2310	Cable
4	"	1/16	.124	"	.028	"	4 1/8	3 1/2	2100	2410	"
5	"	1/16	.124	"	.028	"	3 3/4	3 3/8	2100	2410	"
6	Dipped	1/16	.123	Copper	.028	Open	3 3/4	3 3/4	2100	2440	Cable near termina
7	"	1/16	.123	"	.028	"	4 3/8	3 3/4	2100	2430	" " "
8	"	1/16	.123	"	.028	"	4	4	2100	2450	" " "
9	"	1/16	.124	"	.028	"	4	3 1/2	2100	2440	" " "
10	"	1/16	.123	"	.028	"	4 1/4	4	2100	2440	Cable
11	Dipped and hand finished	1/16	.123	Copper	.028	Open	4	4	2100	2435	Cable near terminal
12	" " " "	1/16	.123	"	.028	"	3 3/4	3 3/4	2100	2435	" " "
13	" " " "	1/16	.123	"	.028	"	4 1/4	4 1/4	2100	2435	Cable
14	" " " "	1/16	.123	"	.028	"	4 1/8	3 3/4	2100	2435	"
15	" " " "	1/16	.123	"	.028	"	4 1/4	4	2100	2450	Cable near terminal
16	None	1/32	.165	"	.039	Close	4 7/8	4 5/8	3200	3950	Terminal
17	"	1/32	.165	"	.039	"	4 1/4	4 1/4	3200	3300	"
18	"	1/32	.165	"	.039	"	4 3/4	4 3/4	3200	3900	"
19	"	1/32	.164	"	.039	"	4 1/4	4 1/4	3200	3500	"
20	"	1/32	.165	"	.039	"	5	4	3200	3930	"
21	Dipped	1/32	.164	Copper	.039	Close	4 1/4	4 1/4	3200	4180	Cable near terminal
22	"	1/32	.164	"	.039	"	4 1/2	4 3/8	3200	4180	" " "
23	"	1/32	.164	"	.039	"	4 5/8	4 1/4	3200	4180	Cable
24	"	1/32	.165	"	.039	"	4 1/2	4 3/8	3200	4190	Cable near terminal
25	"	1/32	.165	"	.039	"	4 1/2	4 3/8	3200	4170	Cable
26	Dipped and hand finished	1/32	.165	Copper	.039	Close	4 1/2	4 1/4	3200	4140	Cable near terminal
27	" " " "	1/32	.165	"	.039	"	4 1/2	4 3/8	3200	4140	" " "
28	" " " "	1/32	.165	"	.039	"	4 1/4	4 1/8	3200	4080	" " "
29	" " " "	1/32	.165	"	.039	"	4 5/8	4 1/4	3200	4130	" " "
30	" " " "	1/32	.166	"	.039	"	4 3/4	4 1/4	3200	4150	" " "
31	Dipped	1/32	.165	Copper	.039	Open	4 1/2	4 1/4	3200	4200	Cable near terminal
32	Dipped and hand finished	1/32	.165	Copper	.039	Open	4 1/2	4 1/2	3200	4160	Cable near terminal
33	None	3/16	.185	Copper	.039	Close	4 1/2	4 1/4	4600	4000	Terminal
34	"	3/16	.184	"	.039	"	5 1/4	5	4600	3370	"
35	"	3/16	.185	"	.039	"	5	4 3/4	4600	3300	"
36	"	3/16	.185	"	.039	"	5	4 3/4	4600	3700	"
37	"	3/16	.184	"	.039	"	5	5	4600	3550	"
38	Dipped	3/16	.185	Copper	.039	Close	4 3/4	4 3/4	4600	5135	Cable near terminal
39	"	3/16	.185	"	.039	"	4 5/8	4 3/8	4600	5125	" " "
40	"	3/16	.184	"	.039	"	5 1/8	4 3/4	4600	5145	" " "
41	"	3/16	.184	"	.039	"	4 3/4	4 3/4	4600	5150	" " "
42	"	3/16	.184	"	.039	"	5	4 1/2	4600	5170	" " "
43	Dipped and hand finished	3/16	.185	Copper	.039	Close	5	4 7/8	4600	5160	Cable near termina
44	" " " "	3/16	.184	"	.039	"	5 1/8	5	4600	5160	" " "
45	" " " "	3/16	.185	"	.039	"	5 1/4	5	4600	5160	" " "
46	" " " "	3/16	.185	"	.039	"	5	4 7/8	4600	5180	" " "
47	Dipped	3/16	.183	Copper	.039	Open	4 3/4	4 1/2	4600	5450	Cable near terminal
48	"	3/16	.183	"	.039	"	4 7/8	4 3/4	4600	5530	" " "
49	Dipped and hand finished	3/16	.185	Copper	.039	Open	4 7/8	4 3/4	4600	5410	Cable near terminal
50	" " " "	3/16	.184	"	.039	"	4 3/4	4 3/4	4600	5380	" " "
51	None	3/16	.184	Steel	.046	Close	4 1/2	4 1/2	4600	2450	Terminal
52	"	3/16	.183	"	.046	"	4 1/2	4 3/8	4600	3560	"
53	Dipped	3/16	.183	Steel	.046	Close	4 1/4	4 1/4	4600	5455	Cable near termina
54	"	3/16	.183	"	.046	"	4 3/4	4 1/2	4600	5500	" " "
55	Dipped and hand finished	3/16	.184	Steel	.046	Close	4 5/8	4 1/2	4600	5420	Cable near terminal
56	" " " "	3/16	.184	"	.046	"	4 5/8	4 3/8	4600	5490	" " "
57	Dipped	3/16	.184	Steel	.046	Open	4 7/8	4 7/8	4600	5500	Cable near terminal
58	"	3/16	.184	"	.046	"	4 3/4	4 1/2	4600	5550	" " "
59	Dipped and hand finished	3/16	.184	Steel	.046	Open	4 3/4	4 3/4	4600	5540	Cable near terminal
60	" " " "	3/16	.184	"	.046	"	4 3/4	4 3/4	4600	5530	" " "

Conclusions

The advantages in using a machine for wrapping cable terminals are well established, both in view of the fact that a tighter and therefore safer wrapping is the result, and because a large saving of time is possible by the machine operation when the quantity of work is great. The Edstrom Wire Wrapping Machine is rigidly but economically constructed, easily operated and should be given a trial where such a machine is desired.

The machine wrapped terminals are over 100 per cent efficient when soldered and at least 60 per cent efficient without

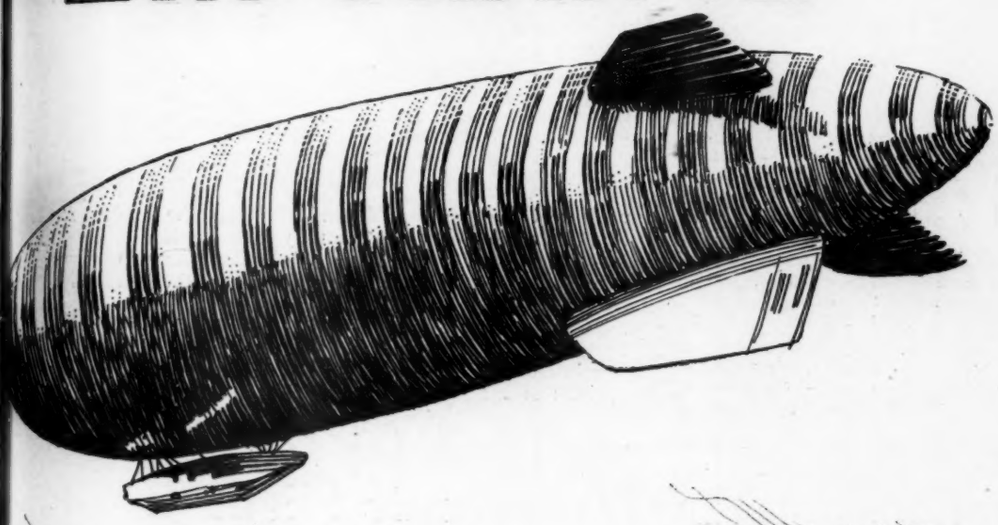
SPEED and



300 H.P.

Hispano-Suiza Aeronautical Engine — Magneto End View

ENDURANCE



The brilliant performances of

HISPANO-SUIZA
Aeronautical Engines

have been substantially recorded on several notable occasions.

These records are milestones in marking the wonderful progress of aeronautical achievement in America.

Manufactured by

Wright-Martin
Aircraft Corporation
New Brunswick, N. J.

TABLE II.
AVERAGE RESULTS

Dia.	How Soldered	Serving Wire	How Served	Rated Strength	Max. Load	Efficiency percent	
1/16	None	Copper	Open	2100	2192	92 Percent	
1/16	Dip	"	"	2100	2440	100 "	+
1/16	Dip & hand fin.	"	"	2100	2440	100 "	+
1/8	None	Copper	Close	3200	3710	100 Percent	
1/8	Dip	"	"	3200	4180	100 "	+
1/8	Dip & hand fin.	"	"	3200	4150	100 "	+
1/8	Dip	Copper	Open	3200	4200	100 "	+
1/8	Dip & hand fin.	"	"	3200	4160	100 "	+
5/16	None	Copper	Close	4600	3660	71 Percent	
5/16	Dip	"	"	4600	5150	100 "	
5/16	Dip & hand fin.	"	"	4600	5170	100 "	
5/16	Dip	Copper	Open	4600	5490	100 "	+
5/16	Dip & hand fin.	"	"	4600	5400	100 "	+
5/16	None	Steel	Close	4600	3010	58 Percent	
5/16	Dip	"	"	4600	5480	100 "	+
5/16	Dip & hand fin.	"	"	4600	5460	100 "	+
5/16	Dip	Steel	Open	4600	5520	100 Percent	+
5/16	Dip & hand fin.	"	"	4600	5530	100 "	+

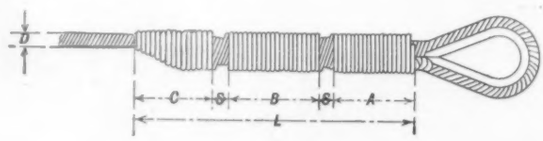
The above efficiencies are approximations based on the strengths of the cables as found in this and other tests where the cable broke, as follows:

Size of Cable	*Assumed Strength*
1/8 in.	2380 lb.
1/4 in.	3700 lb.
5/16 in.	5150 lb.

The actual strengths of the 5/16 in. cables varied considerably as can be seen from the results of the tests where failures occurred in the cable near the terminal. The lower values may have been due to too hot solder.

TABLE III.—SPECIFICATIONS FOR SERVING TERMINALS ON AIRPLANE CABLES.

D	L	A	B	C	S	Diameter of Wrapping Wire
1/16	1 3/4	1/2	1/2	1/2	1/16	.035
1/8	2	1/2	1/2	1/2	1/16	.035
1/8	2 1/2	3/4	3/4	3/4	1/16	.035
1/8	3	7/8	7/8	1	1/16	.035
5/16	3 1/2	1	1	1 1/8	1/16	.035
1/4	4 1/2	1 1/4	1 1/4	1 1/2	1/16	.035



any solder being thus less dependent upon the solder for strength and stiffness than are hand wound terminals.

A small space between each turn of the wrapping wire allows the flux and solder to easily enter all parts of the joint which is essential for maximum efficiency.

Although the strength of the dip soldered terminals was 100 per cent of the cable strength in all these tests, it is nevertheless believed that the hand operation adds to the safety of the joint and is necessary for a well soldered job.

Preparations for the Transatlantic Flight

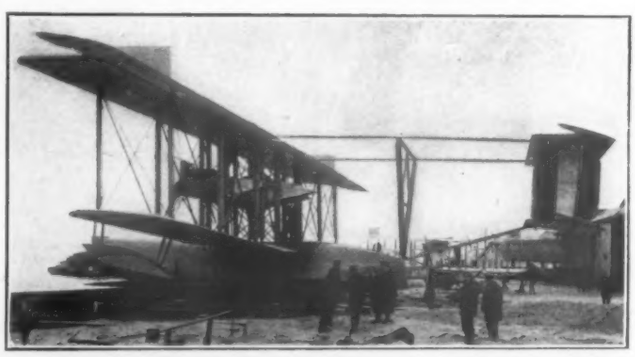
The termination of hostilities and the return to peace time conditions has given new impetus to attempts to cross the Atlantic by means of aircraft.

Just before the war broke out two heavier-than-air craft were being prepared for this attempt: the Curtiss America, a twin-engine flying boat which was to be flown by Lieut. John Porte, R. N., and an English machine, the Martinsyde monoplane.

Now again the United States and Great Britain are the principal contestants for the honor of the first transatlantic flight, though the English preparations are conducted on a much larger scale than our own.

The NC Flying Boats

America is represented in this contest by the United States Navy, which is preparing four flying boats of the NC-class, which are fitted with Liberty engines. Lieut.-Comdr. John H. Towers, U. S. N., is in charge of these preparations.



NAVAL SEAPLANE NC-1, THREE 330 HP. LIBERTY ENGINES

Three of these seaplanes, NC-1, NC-2, and NC-3, are now at the naval air station at Rockaway Beach, where some alterations are being made in the arrangement of the power plant. It is believed that these seaplanes will be re-fitted with two tractor and one pusher airscrews, as against the three tractors originally provided for. The NC-4 is still under construction, but is nearing completion at the plant of the Curtiss Engineering Corp.; this seaplane will have four Liberty engines, arranged in tandem, and driving two tractor and two pusher airscrews.

According to the *New York Times*, the original gasoline consumption provided for a sustained flight of sixteen hours, but changes in the design of the hull interior have allowed for increased storage space substantially increasing the gasoline capacity.

Other changes in the original design contemplate lowering the pilots' station nearer the pontoon so as to facilitate and render less dangerous the changing of pilots in flight.

It is believed that each plane will carry a minimum crew of six men, two of whom will be pilots and the others mechanics and observers. Quarters for the crew, when not engaged in the actual operation of the machine or its repair in flight, have been provided in the hull.

It is expected that the flight will be made at a high altitude, to take advantage of the westerly winds, and the crew will be equipped with heating and respiratory apparatus to allow them to withstand the cold and rarefied atmosphere.

Although the initial start will probably be made from Rockaway Beach, it is expected that the actual jumping-off place will be much farther north, probably at some point in Newfoundland. From this island the distance to the Azores is about 1,200 English miles, and to the west coast of Ireland slightly over 1,900 miles. Which route the NC boats will follow has not yet been determined, but it is believed that preparations will be terminated not later than May 1.*

The "Felixtowe Furies"

The British Royal Air Force, which will officially represent Great Britain in the contest, plans to use both seaplanes and airships in an attempt to cross the Atlantic.

Little is known about the plans of the heavier-than-air branch of the Royal Air Force, except that several machines of the "Felixtowe Fury" class are being tuned up for the great flight. These machines are triplane flying boats fitted with five 350 hp. Rolls-Royce engines; four of these are arranged in two tandem sets, each of which drive a tractor and a pusher airscrew, while the fifth engine, fitted in the middle drives a pusher screw. All the engines are mounted on the middle plane.

British Rigid Airships

More detailed information is at hand regarding the lighter-

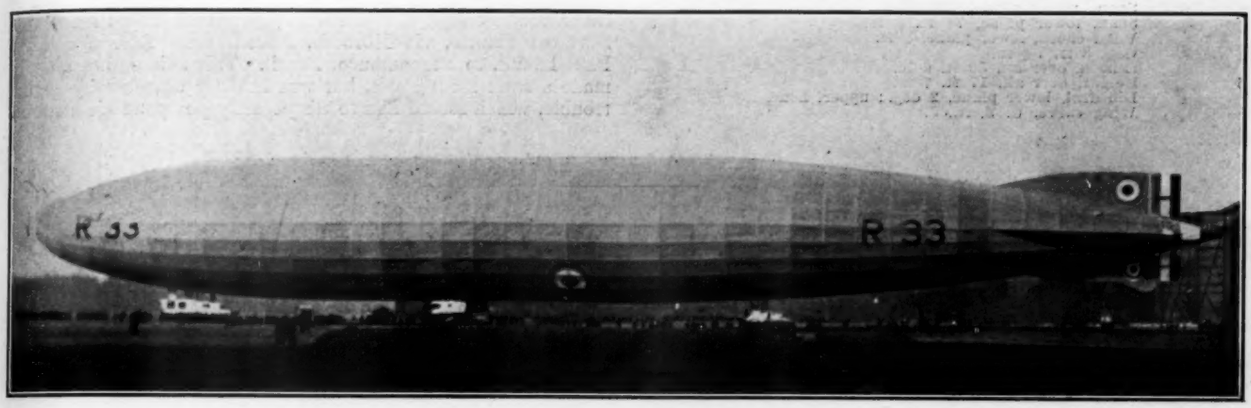
* The general characteristics of the NC-1 flying boat may be found in the Table of Characteristics of American Airplanes and Seaplanes published in the March 1, 1919, issue of AVIATION AND AERONAUTICAL ENGINEERING.

than-air craft the Royal Air Force intends to use in the proposed transatlantic flight.

Several rigid airships of large size are now being fitted out for this attempt. Two of these, the R33 and the R34, built by Armstrong-Whitworth and Beardmore, respectively, have already made their trial flights, while a third airship is nearing completion at the Vickers works.

the Isle of Man, Liverpool and the Midlands and back. In spite of stormy weather, hail, snow and low temperature, which caused the water in the ballast bags to freeze, the R34 was successful in outriding the storms, and in returning to its base after a flight of 19½ hr.

The Vickers airship, which is still on the yards, is smaller than the two foregoing, and is fitted with four Wolseley-



British Rigid Airship R-33, One of the Contestants for the Trans-Atlantic Flight. Capacity, 2,000,000 Cu. Ft. Horsepower, 1250. Speed, 70 M.P.H. Length, 670 Ft. Master Diameter, 79 Ft. Disposable Lift, 29 Tons

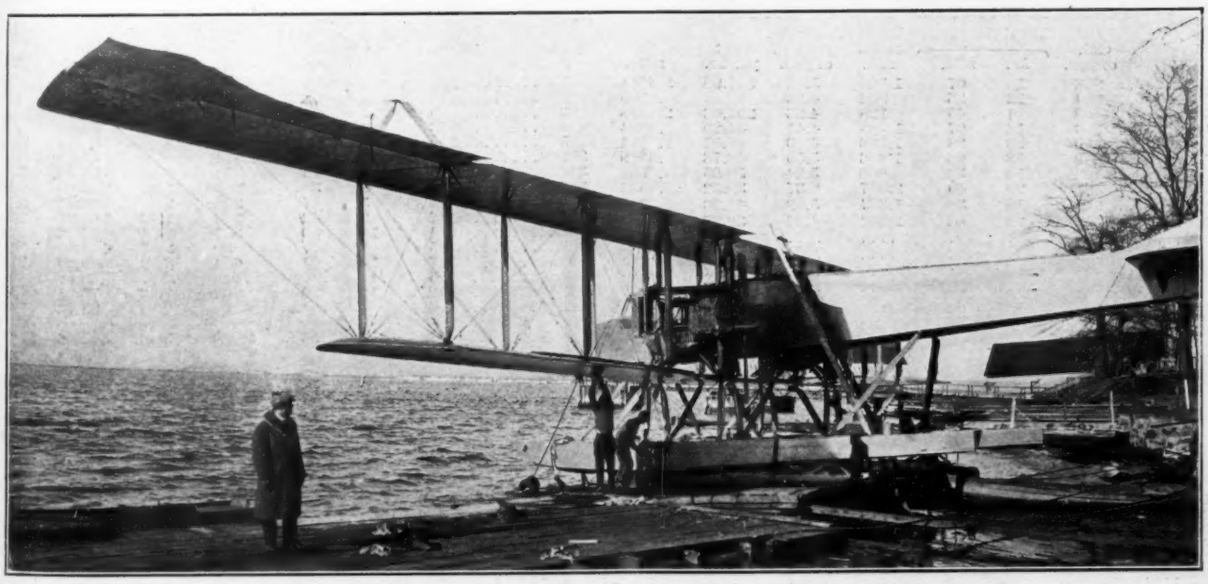
Photo International Film Service

Two more rigid airships of an entirely novel type are also under construction in Great Britain, but as they are not expected to be ready before June it seems likely that they will prove late-comers in the transatlantic race. These vessels will have their engines and accommodations totally enclosed in the hull, and the latter is said to be watertight so the airship can float on the sea if disabled.

The R33 and the R34 are of more conventional design, being built along recent Zeppelin lines, with a well streamlined hull, Maybach engines. Her crew will number sixteen, as against twenty-five for the R33 and R34.

Entrants for the Daily Mail Prize

Beside the projected ventures of the Royal Air Force Great Britain will be represented in the transatlantic flight contest by several civilian aviators who will compete for the $50,000 prize offered by the London *Daily Mail* for the first flight across the Atlantic in either direction.



The Sunstedt Trans-Atlantic Seaplane on the Slipways

cruciform empennage and four cars. Two of these are coaxial, and two are wing cars, like on the Zeppelin L49. The power plant consists of five 250 hp. engines, two of which are mounted in the after car and drive a 19-ft. airscrew; the other cars carry one engine each and drive 16-ft. airscrews.

The R34, which has similar characteristics, recently made an endurance flight which carried her from the Clyde to Dublin,

At the date of writing the entrants are: Harry Hawker and Lieut.-Comdr. McKenzie Grieve, R. N. (Sopwith biplane); Sidney Pickles (Fairey biplane, one 360 hp. Rolls-Royce engine); F. P. Raynham and Capt. C. W. F. Norman (Martinsyde biplane, one 285 hp. engine); an unnamed entry of Short Bros.; and an unnamed entry of a firm whose name is withheld for the time being. All these aviators apparently intend

to start from Newfoundland, where Harry Hawker has already arrived with his machine.

Another contestant for the transatlantic flight is Capt. Hugo Sundstedt, a Swedish aviator, who had a twin-float seaplane built to his designs by the Witteman-Lewis Aircraft Corp. at Newark, N. J. This machine which is now undergoing trials at Bayonne Bay has the following characteristics:

General Characteristics

Span, upper plane, 100 ft.
Span, lower plane, 71 ft. 6 in.
Wind chord, lower plane, 8 ft.
Gap, 8 ft. 7½ in.
Length, over all, 50 ft. 6 in.
Height, over all, 17 ft. 7 in.
Dihedral, lower plane, 2 deg.; upper, none.
Wing curve, U. S. A., 5.
Wing area, 1,537 sq. ft.
Rudder area, 22 sq. ft.
Elevator area, 54 sq. ft.
Weight, 10,000 lbs.
Power loading, 25 lb. per h.p.
Wing loading, 6 lb. per sq. ft.
Speed, estimated, full load, 80 m.p.h.
Climb, estimated, 3,000 ft. in 10 min.
Horsepower, 440.
Engines, two Hall-Scott L-6.
Fuel capacity, 22 hr. at full speed.

Among other contestants for the first transatlantic flight is Lieutenant Fontan, of the French Air Service, who intends to fly from France, via Morocco, French West Africa, and St. Paul Island, to Pernambuco, Brazil. This aviator has already made a start from Paris, but was held up en route by engine trouble, which forced him to temporarily postpone his attempt.

Performance and Cost of the Air Mail Service

COST OF OPERATION AND MAINTENANCE, NOVEMBER, 1918

Airplane No.	Gas.	Grease and Oil.	Office Force.	Motor-cycles, Trucks.	Rent, Light, Fuel, Power, Telephone, and Water.	Misc.	Pilots.	Mechanics and Helpers.	Repairs and Accessories.	Interest on Investment.	Depart-mental Overhead Charge.	Total.
1	$75.60	$14.27	$40.58	$28.37	$33.41	$97.29	$125.90	$149.11	$50.75	$74.78	$83.23	$773.29
2	62.32	7.83	40.58	28.37	33.41	97.29	98.50	188.00	90.11	74.78	83.23	804.42
3	9.15	.81	9.09	28.37	33.41	97.29	13.68	1.70	.35	74.78	83.23	351.86
4	89.94	19.02	40.58	28.37	33.41	97.29	141.53	187.02	7.20	74.78	83.22	802.36
5	111.78	24.40	40.58	28.37	33.42	97.29	206.76	174.88	236.50	74.78	83.22	1,111.98
6	88.02	21.41	40.58	28.37	33.42	97.29	149.21	214.22	63.05	74.78	83.22	893.57
38262....	50.02	8.67	40.58	28.36	33.42	97.29	106.24	151.20	6.86	74.78	83.22	680.64
38274....	97.70	21.18	40.58	28.36	33.42	97.29	225.12	166.39	265.10	74.78	83.22	1,133.14
38275....	80.77	16.47	40.58	28.36	33.42	97.29	153.38	157.65	63.78	74.78	83.22	829.70
38278....	124.97	19.51	40.58	28.36	33.42	97.29	219.13	184.59	18.55	74.78	83.22	924.40
39362....	6.10	....	20.38	28.36	33.42	97.29	....	94.35	4.50	74.79	83.22	442.41
39363....	9.15	....	20.38	28.36	33.42	97.29	....	94.35	5.50	74.79	83.22	446.46
39364....	....	....	20.38	28.36	33.42	97.29	....	94.35	1.20	74.79	83.22	433.01
39365....	21.35	5.21	20.38	28.36	33.42	97.29	....	94.35	2.95	74.79	83.22	461.32
14872....	....	....	9.09	28.36	33.42	97.29	....	255.75	3.20	74.79	83.22	585.12
Totals.	$826.87	$158.78	$464.92	$425.46	$501.26	$1,459.35	$1,439.45	$2,207.91	$819.60	$1,121.75	$1,248.33	$10,673.68

Cost per mile, overhead, $.2746; cost per mile, flying, $.1771; cost per mile, maintenance, $.3277.

SERVICE AND UNIT COST, NOVEMBER, 1918

Airplane No.	Gal. of gas.	Total time run. hr.	Total time run. min.	Total miles run.	Miles run per gal. of gas.	Cost per hr.	Cost per mile.
1	258	16	07	1,504	5.82	$47.98	$.5141
2	204	12	35	992	4.86	63.92	.8109
3	30	1	45	128	4.26	201.06	2.7488
4	296	18	07	1,308	4.41	44.29	.6134
5	400	26	28	1,796	4.49	42.01	.6191
6	289	19	06	1,616	5.59	46.78	.5529
38262.....	164	13	36	860	5.24	50.05	.7914
38274.....	321	28	49	2,047	6.37	39.32	.5535
38275.....	265	19	38	1,384	5.22	42.26	.5394
38278.....	411	28	03	2,034	4.94	32.95	.4544
39362.....	...	...	...	....	....	....	....
39363.....	...	...	...	....	....	....	....
39364.....	...	...	...	....	....	....	....
39365.....	...	...	...	....	....	....	....
14872.....	...	...	...	....	....	....	....
Total...	2,638	184	14	13,689	5.18	$57.93	$.7797

SERVICE AND UNIT COST, DECEMBER, 1918

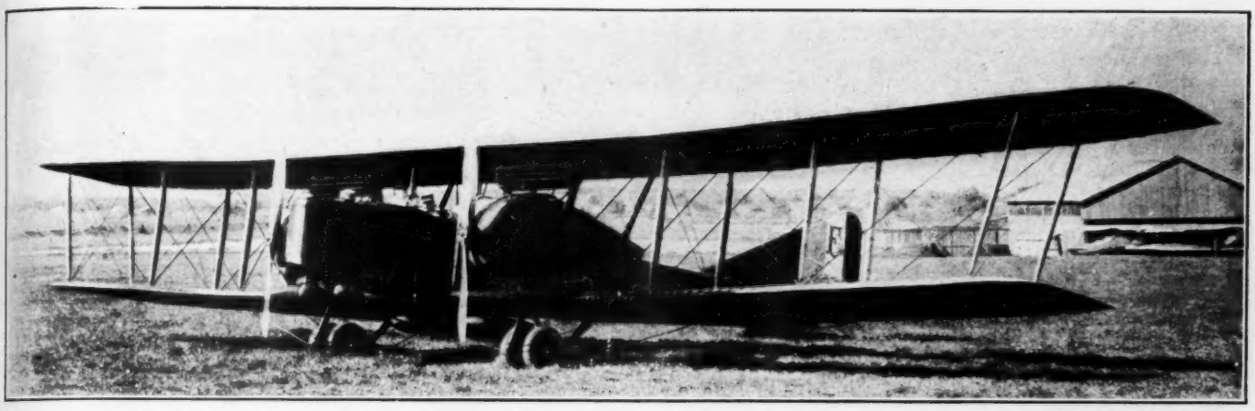
Airplane No.	Gal. of gas.	Total time run. hr.	Total time run. min.	Total miles run.	Miles run per gal. of gas.	Cost per hr.	Cost per mile.
1	122	11	04	839	6.87	$261.53	$3.4496
2	413	23	38	1,706	4.13	48.69	.6746
3	10	...	...	....	....	....	....
4	133	13	19	872	6.55	50.60	.7727
5	150	8	35	223	1.48	68.43	2.6339
38262.....	416	26	14	1,874	4.50	45.02	.6302
38274.....	133	8	13	558	4.19	96.46	1.4203
38275.....	128	2	30	266	2.07	233.09	2.1907
38278.....	111	3	17	238	2.14	184.65	2.5473
39362.....	177	2	42	253	1.42	248.27	2.6495
39363.....	374	10	53	804	2.14	71.86	.9727
39365.....	35	1	...	90	2.57	476.45	5.2938
39366.....	187	10	01	654	3.49	66.00	1.0109
39367.....	35	...	...	....	....	....	....
14872.....	412	10	39	962	2.33	75.35	.8342
24213.....	174	7	51	476	2.73	82.42	1.3593
Total...	3,010	139	56	9,815	3.26	$95.05	$1.3551

COST OF OPERATION AND MAINTENANCE, DECEMBER, 1918

Airplane No.	Gas.	Grease and Oil.	Office Force.	Motor-cycles, Trucks.	Rent, Light, Fuel, Power, Telephone, and Water.	Misc.	Pilots.	Mechanics and Helpers.	Repairs and Accessories.	Interest on Investment.	Depart-mental Overhead Charge.	Total.
1	$38.64	$12.24	$40.21	$63.04	$33.50	$119.76	$94.89	$110.46	$2,226.14*	$70.10	$85.31	$2,894.29
2	129.98	22.24	40.21	63.04	33.50	119.76	202.65	134.40	249.76	70.11	85.31	1,150.96
3	3.00	....	5.56	63.04	33.50	119.76	....	.73	....	70.11	85.31	381.01
4	41.73	6.05	40.21	63.04	33.50	119.76	114.18	92.21	7.70	70.11	85.31	673.80
5	46.05	11.41	13.89	63.04	33.50	119.76	73.59	67.32	3.40	70.11	85.31	587.38
38262....	131.88	26.15	40.21	63.04	33.50	119.76	224.92	169.11	217.18	70.11	85.31	1,181.17
38274....	41.96	7.56	40.21	63.04	33.50	119.76	70.45	102.99	157.66	70.11	85.31	792.55
38275....	40.35	5.64	40.20	63.04	33.50	119.76	21.44	88.88	14.50	70.11	85.31	582.73
38278....	34.06	7.33	13.88	63.04	33.51	119.76	28.15	127.10	24.02	70.11	85.31	606.27
39362....	55.82	15.52	40.21	63.04	33.51	119.77	23.15	153.89	10.00	70.11	85.31	670.33
39363....	119.19	17.17	40.20	63.04	33.51	119.77	93.31	131.48	9.00	70.11	85.31	782.09
39365....	12.30	5.50	26.32	63.04	33.51	119.77	8.57	47.02	5.00	70.11	85.31	476.45
39366....	60.67	11.37	40.20	63.05	33.51	119.77	85.88	90.28	1.00	70.11	85.31	661.15
39367....	10.50	.54	5.56	63.05	33.51	119.77	....	22.36	....	70.11	85.31	410.71
14872....	129.93	20.43	40.21	63.05	33.51	119.77	91.51	133.56	15.15	70.11	85.31	802.54
24213....	54.59	11.13	40.20	63.05	33.51	119.77	67.31	85.85	16.20	70.11	85.31	647.03
Totals.	$950.65	$180.28	$507.48	$1,008.68	$536.08	$1,916.23	$1,200.00	$1,557.64	$2,956.71	$1,121.75	$1,364.96	$13,300.46

Cost per mile, overhead, $.4624; cost per mile, flying, $.2374; cost per mile, maintenance, $.6551.
* Repairs and accessories plane No. 1 include overhauling of damaged motor.

The Farman Model F-50 Bomber



The Farman Model F-50, a product of the largest airplane manufacturing firm of France, is one of the most modern night bombers that have been used by the French Air Service.

The span of the upper wings is 22.85 m., and that of the lower wings 20.40 m.; the chord is uniformly 2.35 m. The outer wing panels, which join the center section in the neighborhood of the engine nacelles, are set at a dihedral of 2 deg. The total wing area is 97 sq. m.

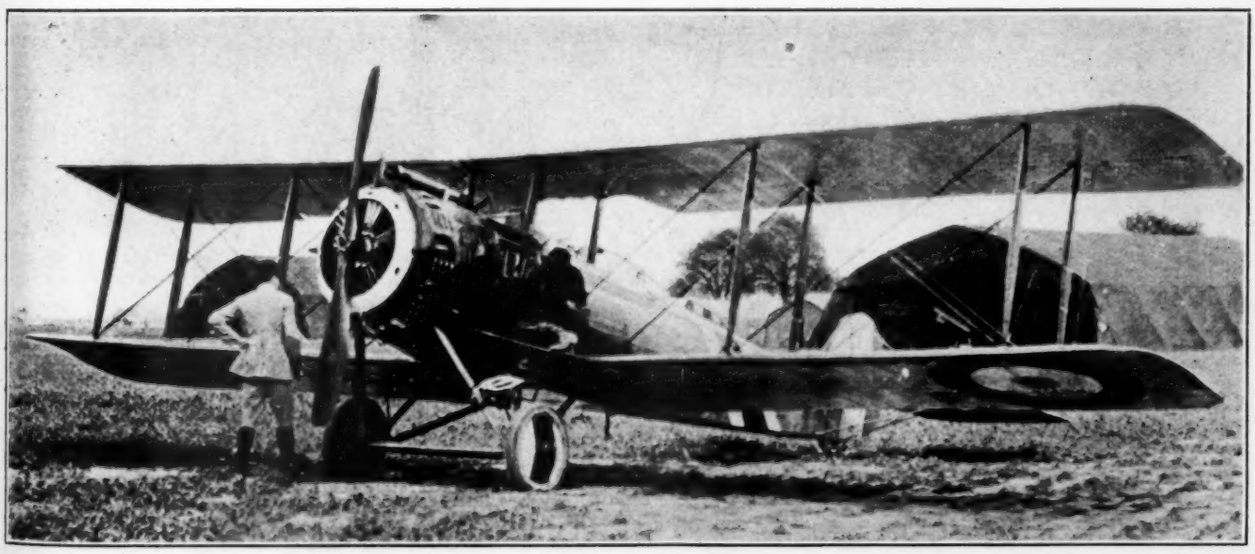
The overall length of the machine is 12.025 m., and the overall height, 3.30 m.

Originally the power plant consisted of two 240 hp. or 275 hp., 8-cylinder Farman (Lorraine-Dietrich license) engines, but more recently this machine has been modified to carry Liberty-12 engines. The cruising speed, fully loaded, is 130 km.p.h.

The armament consists of two machine guns, mounted one each on the forward and after cockpits, and bomb gears which are fitted below the pilot cockpit and are operated by the bomber, who sits next to the pilot on a folding seat.

The machine weighs, empty and without the bomb gears, 1800 kg.; the useful load is 1300 kg., so that the weight, fully loaded, is 3100 kg. The wing loading is therefore 32 kg./sq.m., and the power loading, with two 275 hp. engines, 5.6 kg./hp.

The Salmson, Type 2, Two-Seater Fighter



The Salmson Type 2 military airplane, which is herewith illustrated in three-quarter front view, is one of the more recently commissioned general service machines of the French Air Service. This airplane is a product of the Société des Moteurs Salmson, of Billancourt, France, and is fitted with a 9-cyl. 250 hp. Salmson engine of the radial, water-cooled type. Although the Salmson Co. have been producing airplane engines far back in pre-war days, they have engaged in airplane construction, comparatively speaking, but recently, and the machine under review may be therefore considered as one actually "built around" the engine.

The principal characteristics of the Salmson Type 2 are as follows:

Surfaces: Area of main planes, 37.27 sq.m.; area of elevator, 4.15 sq.m.; area of rudder, 1.33 sq.m.

Power Plant: Engine, 250 hp. Salmson; diameter of airscrew, 2.80 m.; pitch of airscrew, 2.10 m.; airscrew speed, 1400 r.p.m.

Weight items: Weight of machine, empty, 780 kg.; gasoline, for 3 hours, 189 kg.; oil for 3 hours, 11 kg.; pilot and observer, 160 kg.; machine gun with mountings and ammunition, 80 kg.; instruments, 10 kg.; radio and lighting equipment, 72; kg.; total weight in flight, 1,390 kg.

Climb Performance: 1000 m. in 3 min. 18 sec.; 2000 m. in 7 min. 15 sec.; 3000 m. in 11 min. 42 sec.; 4000 m. in 17 min. 20 sec.; 5000 m. in 27 min. 30 sec.

Horizontal Speed: At 1000 m. altitude, 186 km.ph.; 2000 m. altitude, 181 km.ph.; 4000 m. altitude, 173 km.ph.; 5000 m. altitude, 168 km.ph.

Factor of safety: 7.5.

News of the Fortnight

Transcontinental Flight Planned

A new transcontinental flight is planned for the near future. Major Tom C. McCauley intends to use the Southern route and double the continent, San Diego, Cal., to Savannah, Ga., distance about 2,460 miles each way, via Americus and Fort Worth, Texas. He will use the DH-4, fitted with extra gasoline tanks, stopping at fields en route to change planes. He hopes to average over 1200 miles a day and double the continent in four days.

Major McCauley contemplates starting from Fort Worth, Texas, and make a non-stop flight to Souther Field, 1109 miles; change planes and go on to Savannah, 174 miles—this in one day. Returning he will pick up a plane again at Americus and continue on to Fort Worth. Thence to San Diego and return to Fort Worth, where he is stationed.

Dropping Photographs from the Air

A method of dropping photographs from the air so that they will not be injured when hitting the ground is being tried out by the Photographic Branch of the Training Section, D. M. A.

This method consists of placing the photographs in a mailing tube which is left open at both ends and through which a tape fastened at one end is passed. To the other end a weight is attached, which, with the air rushing through the open ends, causes the tube to fall perpendicularly.

Tests have been made at the Army War College and are reported to have proved very successful.

Naval Air Mission Goes Abroad

Secretary of the Navy Daniels sailed for Europe on March 14 with Rear Admirals Robert S. Griffin, Chief Engineer, U. S. N., David W. Taylor, Chief Constructor, U. S. N., and Ralph Earle, Chief of Ordnance, U. S. N.

Secretary Daniels and his three advisers will give particular attention to aircraft development in France, Great Britain and Italy, and upon their return will ask Congress to make a special appropriation to keep the naval air fleet up to date. Definite plans for extensive experimental work with aircraft are now being worked out by the General Board of the Navy.

Air Transport in New Zealand

Extensive plans are being made in New Zealand with a view to applying airplanes and seaplanes to public transportation. The Minister of Post and Telegraphs recently stated that he intends to establish aerial mail lines throughout New Zealand; demobilized military aviators will be employed in this service. The machines which will be used for this purpose are to be overland machines equipped with single engines of 125 and 200 hp. respectively, and flying boats fitted with twin engines of 250 and 400 hp.

On the other hand the New Zealand Flying School, of Auckland, N. Z., is making preparations for the establishment of commercial air lines. It is intended to build various single and twin engine flying boats as well as overland airplanes, and these will be equipped with the Hall Scott Model L-6, 200 hp. engine. As part of their program it is planned to build a large flying boat with which it will be attempted to fly from New Zealand to Australia.

The Paris Air Conference

The British Commission on International Control of Ports, Waterways, and Railways, is considering a proposed assertion of jurisdiction over aerial international flights. The British Air Ministry has prepared an elaborate convention which will be submitted to the Peace Conference.

The International Air Conference in Paris will also take up questions of great importance, such as how far national control of the air may go, passports, customs, reciprocal landing facilities, aerial police, and the settlement of damages. Civilian flights between nations are now impossible, because of the absence of essential regulations. Many enterprises, such as the establishment a Paris to London commercial air service, have been delayed in consequence.

The United States will be represented by Brig.-Gen. Mason Patrick, Dr. Wm. F. Durand of the National Advisory Committee on Aeronautics, and Rear Admiral H. S. Knapp.

Major Philip J. Roosevelt Home

Major Philip J. Roosevelt returned to duty in the United States on March 11.

While overseas he was Operations Officer of First Pursuit Group; later of the First Army, and finally Operations Officer of the First Pursuit Wing, First Army. He was decorated with the *Croix de Guerre* at Chateau-Thierry in July, 1918, and served with the American Air Force in the St. Mihel and Argonne offensives.

In 1916 Major Roosevelt was corporal of the First Aero Company, New York National Guard. Before entering the service Major Roosevelt was Military Editor of AVIATION AND AERONAUTICAL ENGINEERING.

International Air Service Club

Officers were elected by the members of the International Air Service Club, meeting for the first time in their new home, 9 and 11 East Thirty-eighth Street. Lawrence La T. Driggs was chosen president, Major Gen. Leonard Wood first vice-president, and Capt. Edward Rickenbacker, second vice-president.

The Directors elected were Capt. Roy N. Francis, Capt. Clifford B. Harmon, Lieut.-Col. Harold E. Hartney, Major Frank H. Page, Lieut.-Commander H. W. Schofield, Major George R. Wadsworth, General Wood, Captain Rickenbacker and Mr. Driggs. Directors from what is called the civilian section were A. L. Haustetter, Lester P. Barlow, Gutzon Borglum, Frank G. Diffin, Charles M. Manly, Robert H. Sexton and Chance M. Vought. The club has taken a lease on two attractive houses in Thirty-eighth Street and offers accommodations for about fifty aviators.

Permanent Aircraft Exhibit

It was announced at the close of the Aeronautical Exposition that a number of the exhibits will be sent to Washington to become the nucleus of a permanent exposition at the United States National Museum.

Under direction of Dr. Charles D. Walcott, secretary of the Smithsonian Institute, plans for a permanent War Exposition in Washington have been under way for some time and are now definitely arranged.

Fast Flying Boat Trip

Two of the navy's flying boats of the F-5-L type, one of them carrying six men and the other five, flew March 12 from Hampton Roads, Va., to the naval station at Rockaway, a distance of 300 miles, in 270 minutes.

The two seaplanes left Hampton Roads at 10 a. m. and landed four and a half hours later at Rockaway. The first boat was piloted by Ensign R. Southers, who carried with him, in addition to Lieut.-Comdr. H. C. Richardson, three enlisted men as passengers. Ensign Irvine piloted the second plane, which carried five navy men.

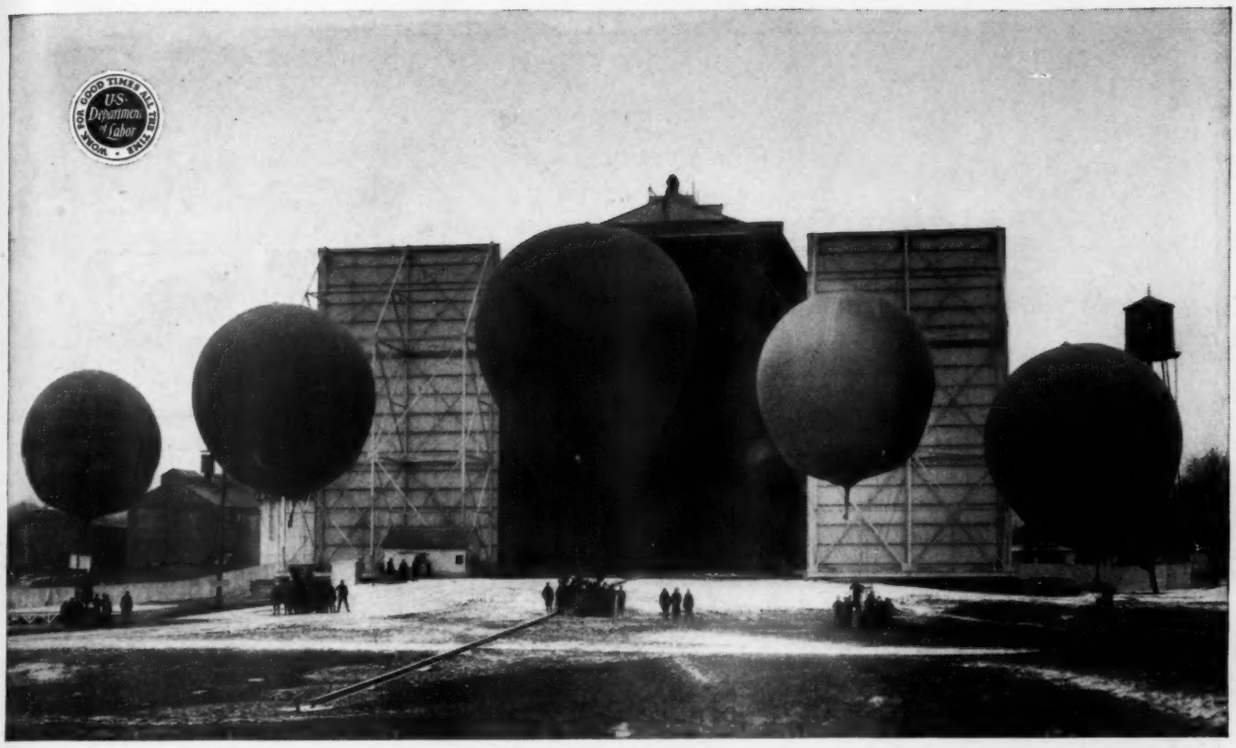
First American Pleasure Aircraft

The purchase of the first American pleasure aircraft is announced from Baraboo, Wis., F. R. McFetridge, of that city, having placed an order for a Packard-Lepère two-seater airplane of the cruiser type. The machine will cost between $12,000 and $15,000.

MacCoull with Texas Co.

Neil MacCoull has returned from duty in France with the Naval Air Forces, and is now connected with the Texas Company as Automotive Engineer in the Sales Department, with headquarters at New York.

Mr. MacCoull has been connected with the design and development of automotive engines for several years, and just prior to enlisting he was acting as a mechanical engineer with the Machine Works of the Westinghouse Electric & Manufacturing Co. of Pittsburgh.



Merely the Fore-Runners

The eight hundred full-size balloons that The Goodyear Tire & Rubber Company has manufactured during the last nine years can only be regarded as the fore-runners of third dimension transport.

Just as the early spherical balloons have been succeeded by larger and more practical types, so will the dirigibles of today be merely modest precedents for tomorrow.

We are confident that the day is not far distant when passenger travel by air will be an established reality—established on a commercial basis as one of the necessary forms of modern transportation.

We are prepared for the great future.

For nine years The Goodyear Tire & Rubber Company has been the leading manufacturer of rubberized balloon fabric in America.

This supremacy has naturally led to pioneering the development of craft lighter than air.

It has produced a body of Goodyear workmen who are truly balloon craftsmen.

It has developed aeronautic engineers and designers of unquestioned competence and authority.

Balloons of every standard size and type—spherical, advertising, kite and dirigible—are constantly being produced in the Goodyear factory and tested over the Goodyear Aviation Field.

On special sizes we are prepared to submit plans and specifications for any type of lighter-than-air craft—from miniature models to huge Trans-Atlantic Liners.

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Aerial Use

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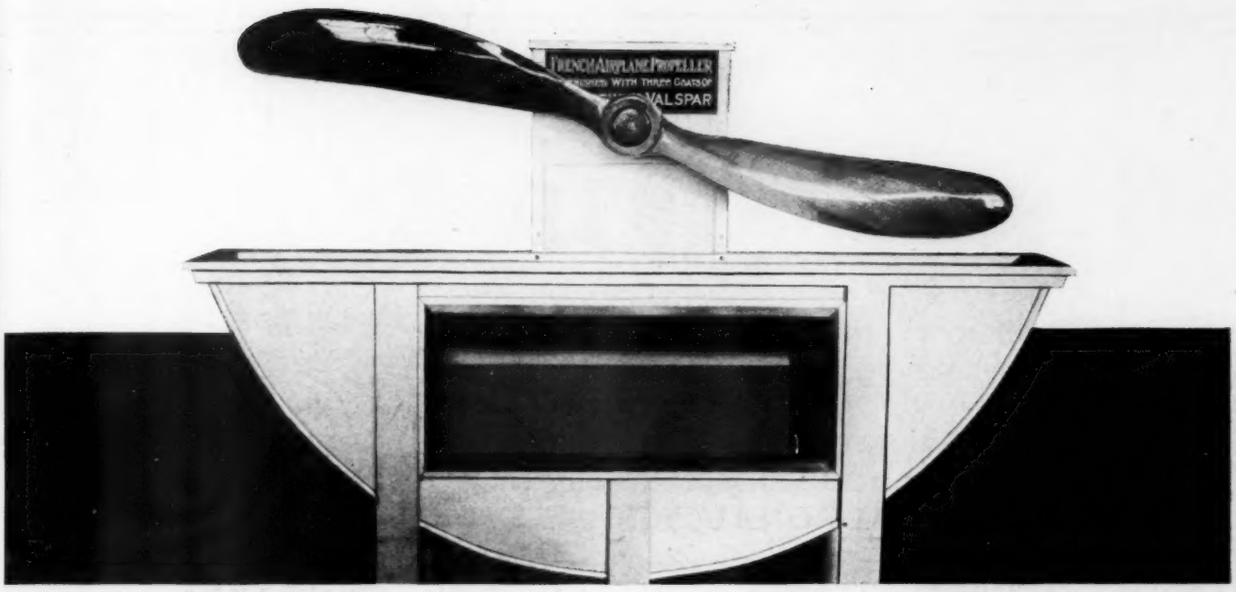

An Experiment they *Dared* us to make—

"Take a laminated airplane propeller; varnish it with Valspar; mount it so that the blades will pass through a tank of water at each revolution; hitch a motor to it; run it for a week."

That's what some varnish "sharps" dared us to do. They knew that this was one of the most severe tests that you could give a varnish to prove whether or not it was *absolutely* water-proof.

It is much more severe than an ordinary soaking test because the water pushes against the propeller blades, trying to drive through the varnish. If any water seeped through the varnish and got into the glue between the walnut strips, the propeller would promptly begin to go to pieces.

To these varnish "sharps" this was a *dare*; to us it was nothing more than a demonstration, because we knew that Valspar could stand *any* water test that might be suggested.

So we accepted their dare

We got a laminated French airplane propeller and gave it three coats of Valspar. Then we mounted it, as shown in the photograph above, geared to a motor so that it revolved continuously, the blades being exposed alternately to water and air at each revolution.

For *two years*, off and on, this propeller has revolved, forcing its way through the water. And nothing has happened!

The propeller blade not only looks as fresh and bright as it did the first day it started to revolve, but it looks as though the test could be continued for *years* without any possibility of the wood or the glue ever getting even damp.

Airplane engineers can readily understand the importance of this unusual water-proof quality of Valspar, for when driving through mist banks or through rain-storms, the impact of the water against the varnished surfaces of airplanes, and particularly the propeller, is *terrific*, and unless the varnish is *absolutely water-proof* and will positively prevent any moisture driving through it, there is danger of serious consequences.

TO Purchasing Agents and Superintendents of Production: **Our airplane Department willingly places its experience at your disposal. We have a valuable book full of information on airplane finishing which we will be glad to hand you on request**

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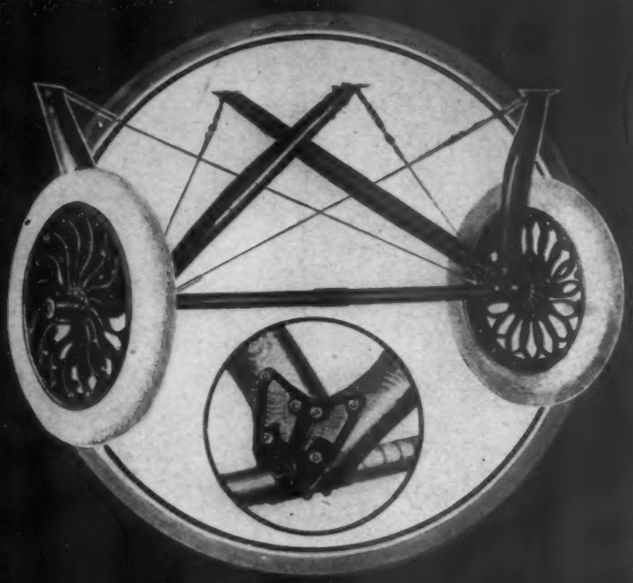

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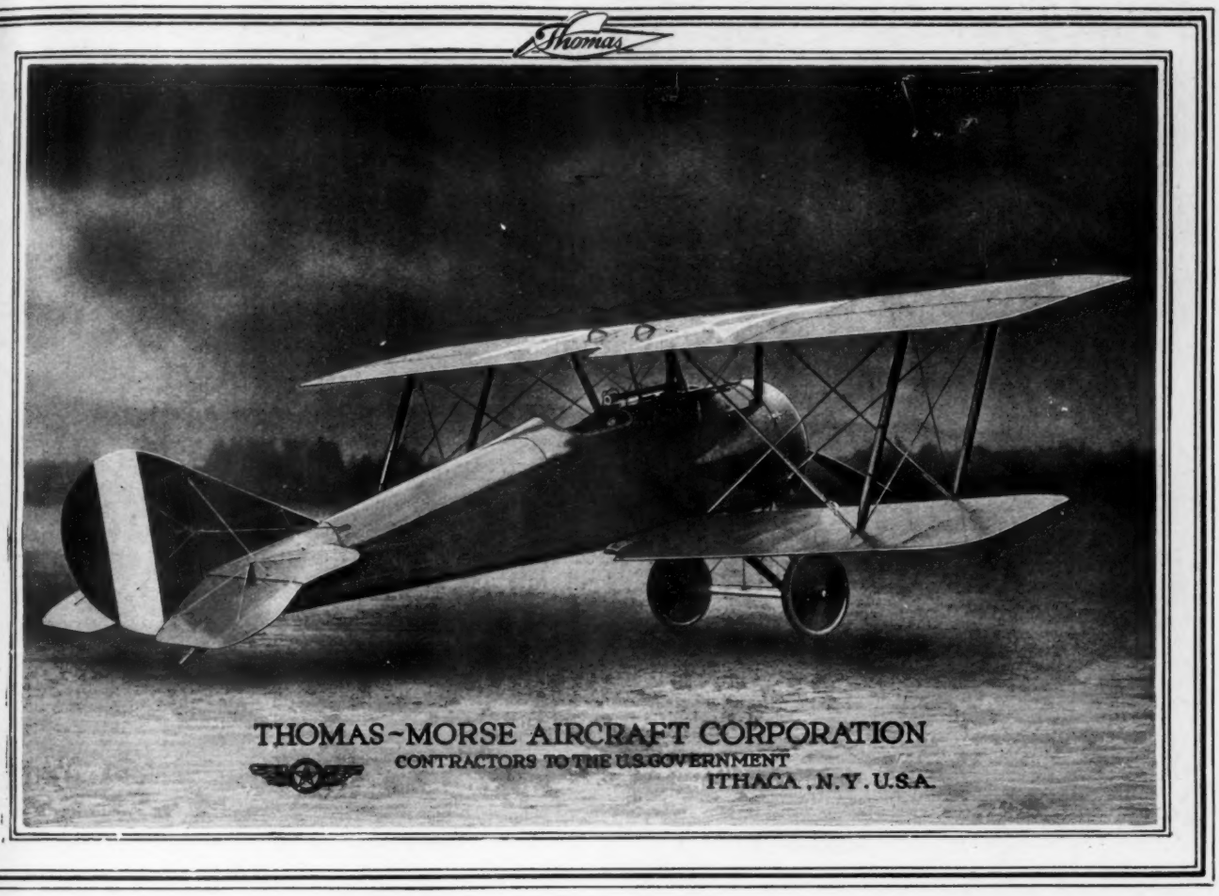

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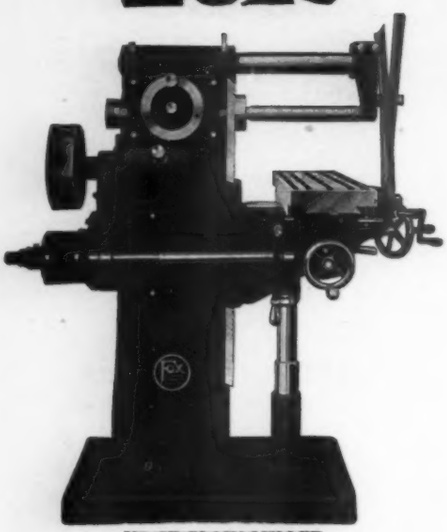

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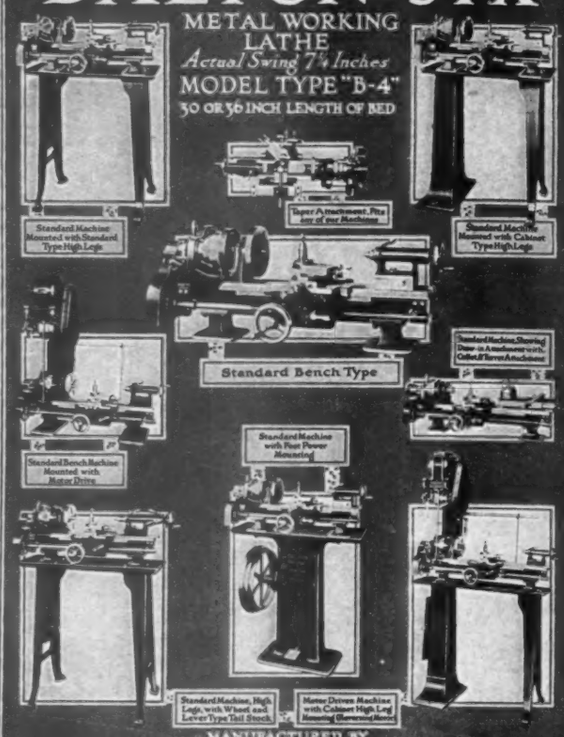

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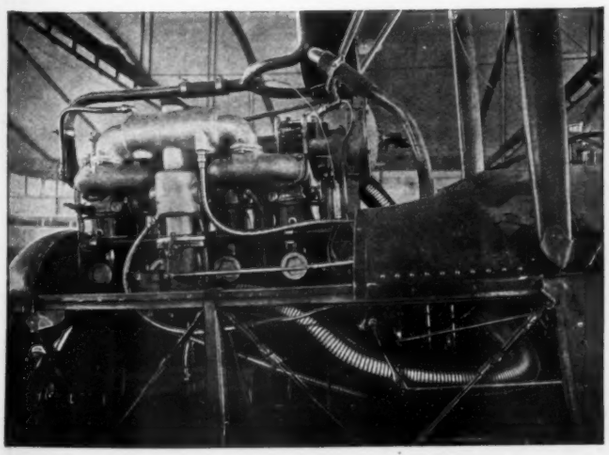

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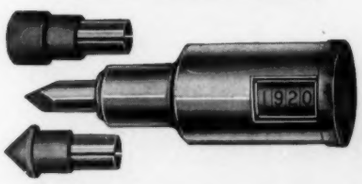

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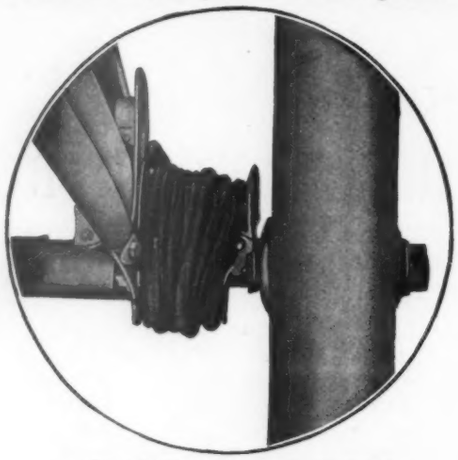

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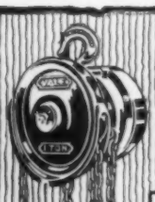

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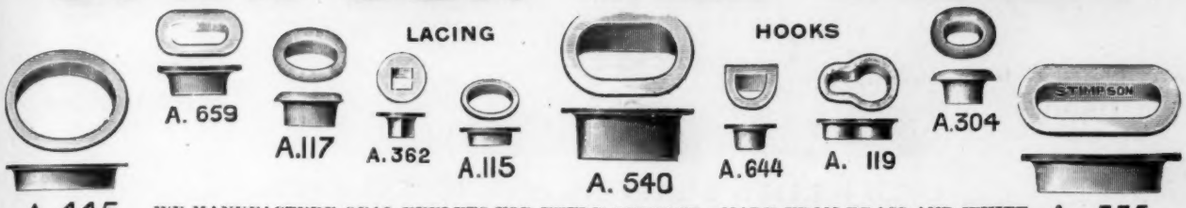

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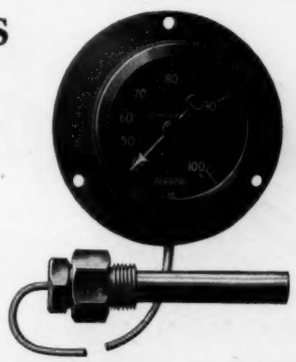

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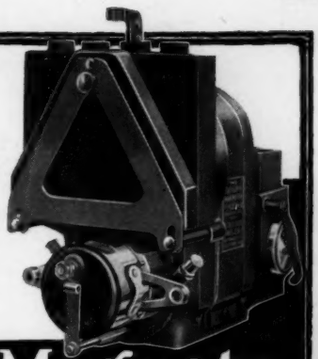

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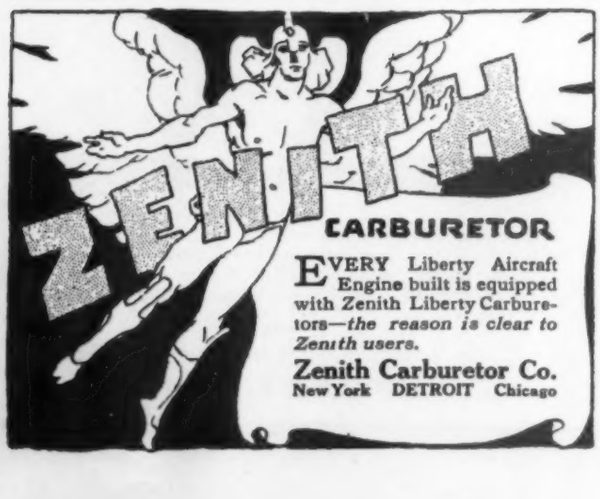
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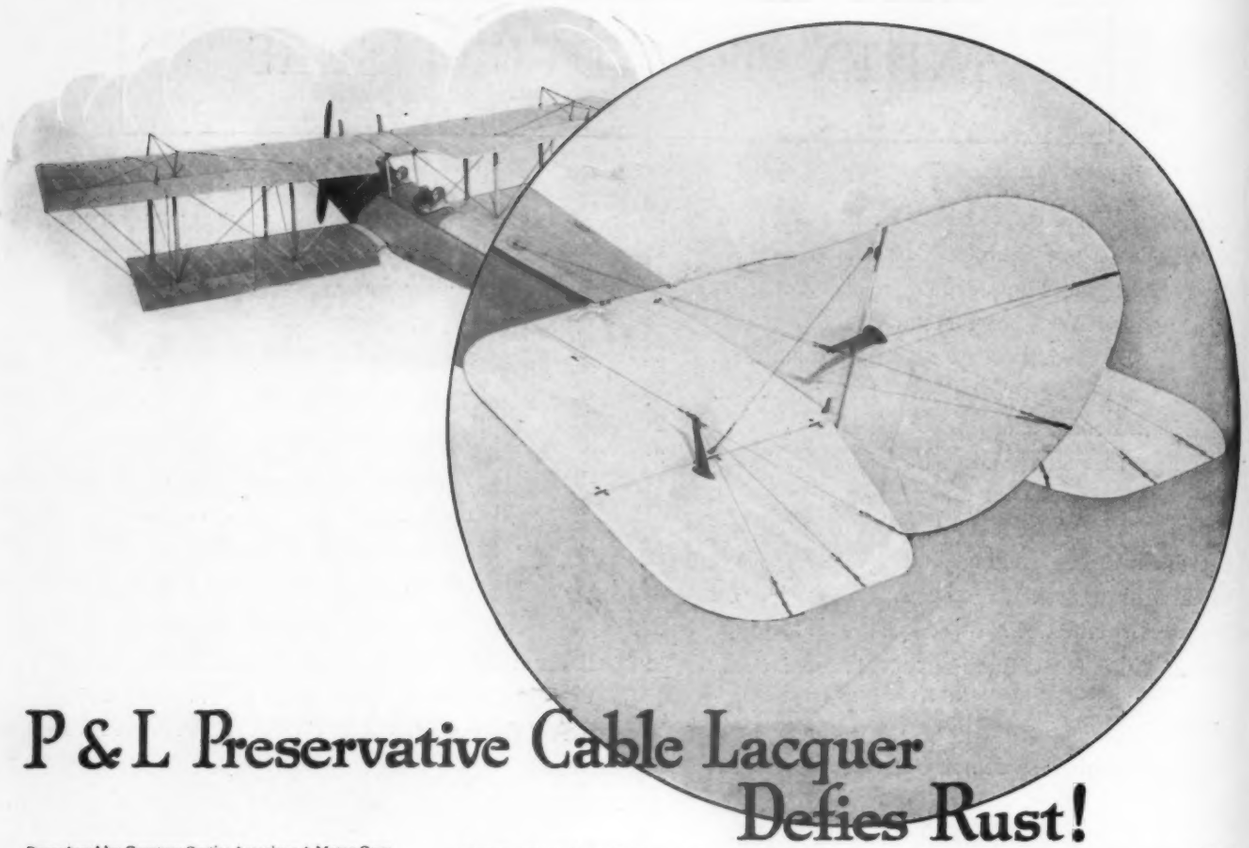

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